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Southern cropping region trial results 2014

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Foreword

NSW Department of Primary Industries (NSW DPI) welcomes you to the inaugural edition of the *Southern cropping region trial results 2014*. This book has been produced to increase awareness of research and development (R&D) activities undertaken by NSW DPI in the southern cropping region of NSW. It delivers the outcomes of these activities to our stakeholders including agribusiness, consultants and growers.

This document will become a comprehensive, annual report of NSW DPI's R&D work in southern NSW.

NSW DPI, in collaboration with our major funding partner GRDC, is at the forefront of agricultural research in the southern cropping region of NSW. Our R&D teams conduct applied, scientifically sound, independent research to advance the profitability and sustainability of our farming systems.

The Department's major research centres in the southern region of NSW are Wagga Wagga, Yanco, Condobolin and Cowra where our team of highly reputable research and development officers and support staff are based. The regional geographic spread of the research centres allows for experiments to be replicated across high, medium and low rainfall zones with Yanco providing the opportunity to conduct irrigated experiments.

The Southern Cropping Systems Unit's research program includes the areas of germplasm improvement; farming systems management e.g. nutrient management, agronomy, water use efficiency and crop sequencing; plant protection e.g. entomology, pathology and integrated weed management; and supply chains and market access. The following papers provide an insight into selected R&D activities taking place in the southern region. We hope you will find them interesting and valuable to your farming system or the farming clients you work with.

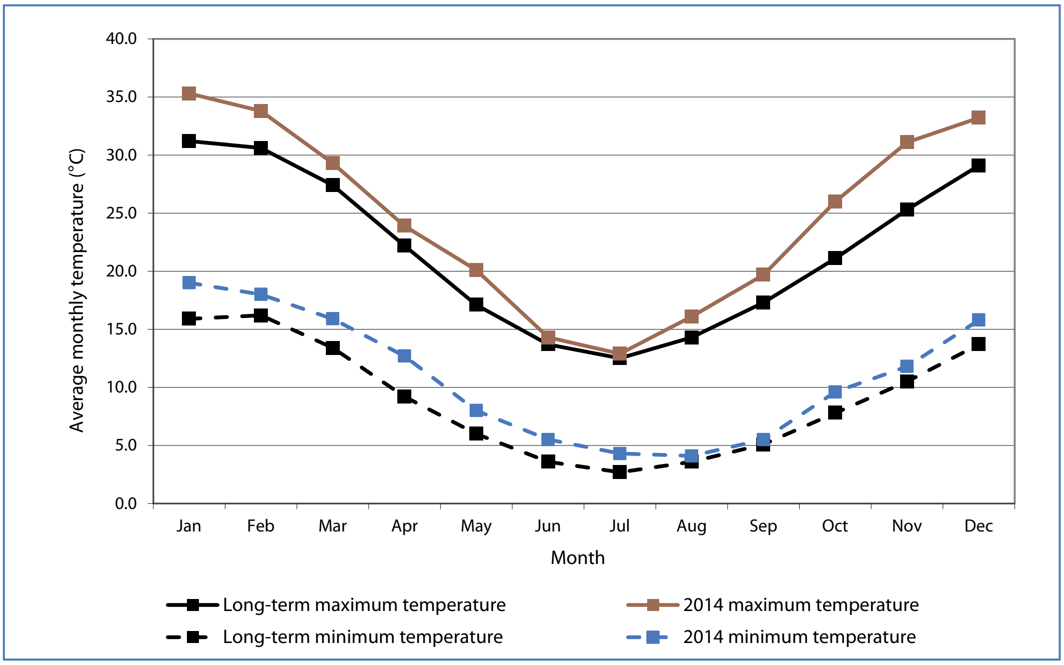
We acknowledge the many collaborators (growers, agribusiness and consultants) that make this research possible. We also encourage feedback to help us produce improved editions in future years.

The Research and Development Team
Southern Cropping Systems Unit
NSW Department of Primary Industries

Seasonal conditions—2014

The 2014 season was characterised by a dry, warm, quick spring that caused many crops to mature approximately 2–3 weeks earlier than normal, while also keeping disease pressure generally low. There were also a high number of frost events (including severe frosts) that caused substantial crop damage, especially in the early sown crops. There were 15 mornings with a minimum temperature of below -1.0°C in July and August with the coldest recorded temperature of -4°C occurring on 5 August.

The growing season rainfall (April-October) in 2014 was 278 mm which is 15% below the long-term average of 328 mm. Rainfall during July, August, September and October, the main flowering and grain-filling period, was only 93 mm – 50% below the long-term average of 195 mm. Additionally, maximum and minimum temperatures for the same period were approximately 2°C above the long-term average (*Figure 1*).



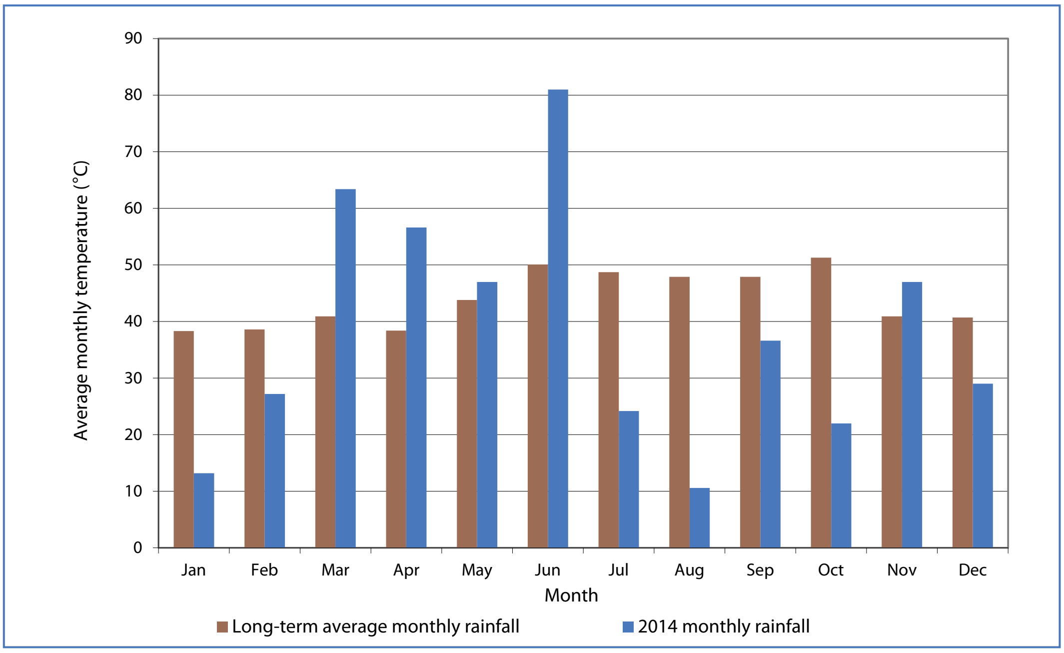


Figure 1: Long-term average and 2014 monthly temperature (top) and rainfall (bottom) and temperature data for Wagga Wagga Agricultural Institute.

Contents

Summer weeds reduce moisture and nitrogen—Forbes 2011 and 2012

Colin McMaster NSW DPI, Cowra and
Dr Neroli Graham NSW DPI, Tamworth

Introduction

The aim of this experiment was to evaluate the impact of summer weeds on stored soil moisture, nutrient retention and grain yield of the following crop.

This experiment is part of a series of summer fallow management experiments through the Central West Farming Systems *Rain n Grain* project

Previous NSW DPI research conducted in central NSW found that 50% of yield potential can be attributed to summer rainfall and summer fallow management (*Haskins and McMaster, 2012*).

Summer weed control was found to be more important than stubble management as clean, weed-free fallows increased both soil moisture and nutrient availability. A dollar invested in fallow sprays averaged a $3.90 gross return across three sites (*Haskins and McMaster, 2012*).

Treatments

The experiment site was located 30 km north west of Forbes NSW. It was comprised of three replicates of each combination of summer weed control (*Table 1*) and additional nitrogen fertiliser (*Table 2*).

Table 1: Summer weed control treatments.

Treatment	Protocol
Nil spray	No summer spray (knockdown applied just prior to sowing)
Miss first spray	The first initial spray of the fallow period was not applied. The remaining spray treatments were the same as the full spray treatment.
Full spray	Zero tolerance to weeds with herbicide applied approximately 10 days after significant rainfall event*
Delayed spray	Herbicides applied approximately 24 days after significant rainfall event*

* A significant rainfall event was considered to be >20 mm.

Table 2: Rates of applied additional nitrogen fertiliser treatments.

2011 (kg N/ha)[a]	2012 (kg N/ha)[d]
0	0
70[b]	50
140[c]	100

[a] Additional N applied as urea ammonium nitrate (UAN) using streaming nozzles.

[b] Applied at early budding.

[c] 70 kg N/ha applied at early budding and additional 70 kg N/ha at stem elongation.

[d] All additional nitrogen applied in 2012 was pre-drilled urea.

Key findings

In 2011, 58% of canola (Hyola® 575CL) grain yield was attributed to increased stored soil moisture and nitrogen retained from a weed-free fallow.

- Controlling summer weeds increased:
  - canola grain yield by 0.83 t/ha where full weed control was implemented
  - plant available water (PAW) at sowing by 86 mm and 50 mm in 2011 and 2012, respectively
  - mineral nitrogen by 69 and 45 kg N/ha in 2011 and 2012, respectively.
- For every 1 mm of moisture lost through summer weed growth, mineral nitrogen levels were reduced by approximately 0.56 kg N/ha.
- Summer weeds used soil moisture to a depth of at least 1.2 m.
- Every dollar invested in controlling summer weeds returned up to $7.20/ha.
- Where full fallow weed control was implemented, the return on investment (ROI) was up to 720%.

Results

Moisture retention

Controlling summer weeds through the application of herbicide spray had a significant effect on stored moisture in 2011 ($P=0.009$) and 2012 ($P=0.021$).

There was a benefit of 86 mm and 50 mm PAW, for 2011 and 2012 respectively, at sowing when summer weeds had been fully controlled when compared with the nil spray treatment (*Table 4*).

Stored PAW in 2011 for the full (201 mm PAW) or delayed (167 mm PAW) was greater than either the missed first (122 mm PAW) or nil (115 mm PAW) spray treatments (*Table 4*). In 2012, the delayed spray treatment stored the most moisture (159 mm) followed by the miss first spray (155 mm), full spray (147 mm) and nil spray (97 mm) (*Table 4*). There was no significant difference in stored moisture between the missed spray, delayed spray and full spray treatments due to high rainfall in 2012 (*Table 3*).

In both 2011 and 2012 the additional PAW was largely conserved between the depths of 15 cm and 105 cm (*Figures 1* and *2*). Summer weeds in the nil spray treatment reduced PAW to a depth of 120 cm (*Figures 1* and *2*).

Residual moisture (115 mm PAW) was measured after the 2011 harvest with no difference between the spray treatments (data not shown).

Nutrient retention

Nitrogen (mineral N)

Summer weed growth had a significant effect on available soil nitrogen at sowing in 2011 (P=0.02) and 2012 (P=0.007) (*Figures 3* and *4*).

Zero tolerance for summer weed growth increased the level of mineral nitrogen by 69 kg N/ha in 2011 and 45 kg N/ha in 2012.

Nitrogen losses increased as weed control was delayed, missed or nil spray in 2011, when compared with full spray treatment (*Table 5*). The nil spray treatment had lower mineral nitrogen levels in the soil when compared to the other three spray treatments (*Table 5*). Increased nitrogen levels were evenly distributed throughout the whole soil profile (*Figure 3* and *4*).

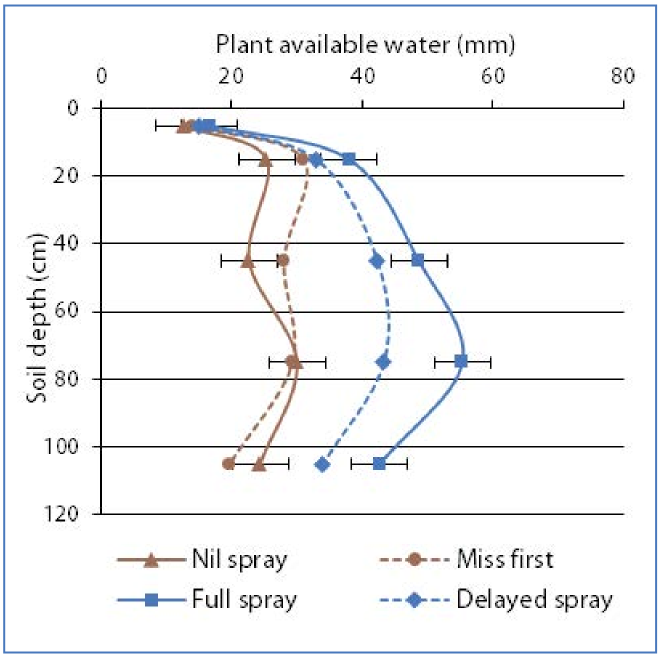


Figure 1: Plant available water (mm) and standard error for the four spray treatments in 2011.

Table 3 Monthly rainfall (mm) at Gunningbland.

Month	2011 mm	2011 Decile	2012 mm	2012 Decile
January	8	1.0	35	3.8
February	70	7.2	179	9.8
March	83	8.5	128	9.4
April	25	4.4	37	5.8
May	34	4.3	60	7.2
June	12	0.7	44	5.1
July	17	1.5	43	4.6
August	57	6.6	15	1.1
September	23	3.0	33	4.5
October	56	6.3	7	0.4
November	139	9.7	18	2.4
December	102	8.9	14	1.5
Total rainfall	626		613	
In-crop rainfall*	136		202	

*In-crop rainfall includes May to October rainfall

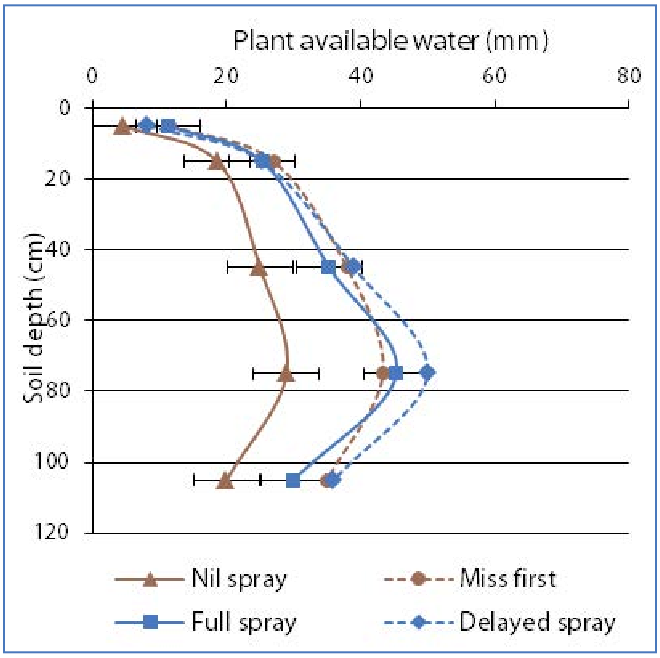


Figure 2: Plant available water (mm) and standard error for the four spray treatments in 2012.

Table 4 Plant available water (mm) for each of the four spray treatments measured at sowing.

Spray treatment	2011 PAW (mm)	2012 PAW (mm)
Nil spray	115.5	97.3
Miss first spray	121.6	155.0
Full spray	201.3	147.3
Delayed spray	167.6	158.7
LSD (P=0.05)	43.2	37.2

Table 5 Level of mineral nitrogen (kg N/ha) measured at sowing for four spray treatments.

Spray treatment	2011 nitrogen (kg/ha)	2012 nitrogen (kg/ha)
Nil spray	44.4	80.4
Miss first spray	72.2	120.6
Full spray	113.8	125.0
Delayed spray	81.7	112.9
LSD (P=0.05)	36.0	20.9

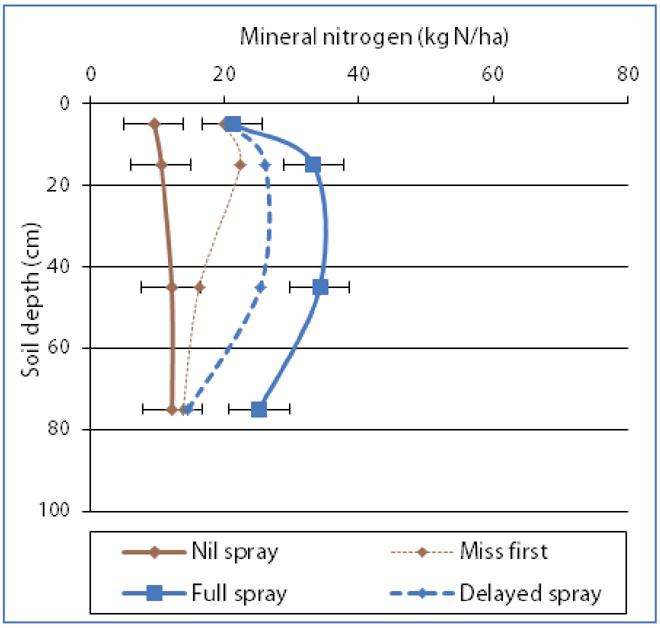


Figure 3: Mineral N (kg N/ha) and standard error for the four spray treatments in 2011.

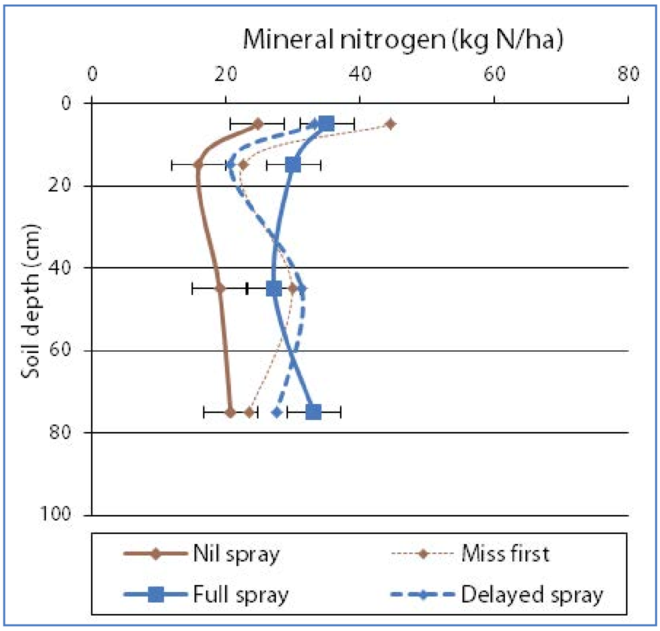


Figure 4: Mineral N (kg N/ha) and standard error for the four spray treatments in 2012.

Phosphorus (Colwell P), Potassium (Colwell K) and Sulphur (KCL)

Control of summer weed growth did not influence the level of soil phosphorus, potassium or sulphur levels in 2011 or 2012 (*Table 6*).

Relationship between moisture and nutrient retention in 2011 and 2012

A strong relationship (R^2=0.62) was observed between PAW and nitrogen availability at sowing. For every millimetre of moisture lost through summer weed growth, mineral nitrogen levels were reduced by 0.56 kg/ha. For example, if 75 mm of soil moisture was conserved by controlling summer weeds, there was 42 kg/ha of additional nitrogen available for the following winter crop (*Figure 5*). The additional nitrogen was likely due to increased mineralisation from greater moisture in the soil surface, as well as reduced nitrogen removal by weeds in the absence of summer weed growth.

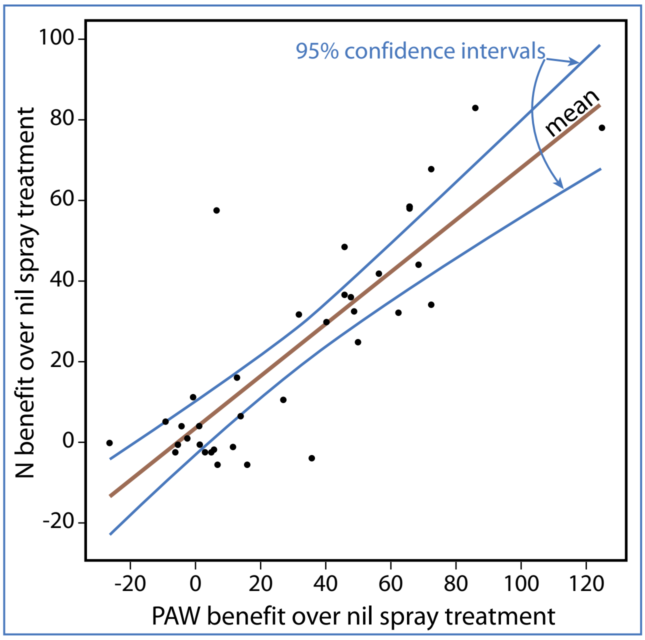


Figure 5: Fitted and observed relationships between moisture (PAW mm) and nitrogen (Mineral N, kg N/ha) loss via summer weed growth with 95% confidence intervals (across 2011 and 2012).

The effect of summer weed growth and additional nitrogen fertiliser on grain yield, protein and oil content

Differences in grain yield as a result of summer weed control (P<0.001), additional nitrogen fertiliser (P<0.001) and their interaction (p=0.004) were observed in 2011.

Grain yields for full spray (1.78 t/ha), and delayed spray (1.75 t/ha) treatments were higher than either missed first spray (1.26 t/ha) or nil spray (0.95 t/ha) treatments.

Nitrogen fertiliser increased grain yield from 1.10 t/ha to 1.43 t/ha and 1.78 t/ha respectively for 0 kg N/ha, 70 kg N/ha and 140 kg N/ha. The effectiveness of additional fertiliser on grain yield varied with summer weed control. Nitrogen fertiliser coupled with good summer weed control (increased stored moisture) showed higher grain yields compared with when nitrogen fertiliser was applied to weedy fallow plots (low stored moisture), (*Figure 6*).

The experiment in 2012 was not harvested due to misadventure resulting in the blending of plots (contract harvester went through site in the dark).

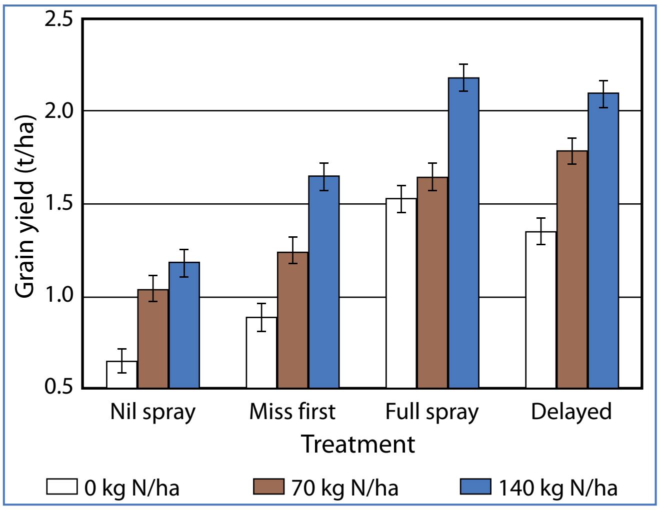


Figure 6: 2011 canola grain yield (t/ha) and standard error for the four spray and three nitrogen fertiliser treatments.

Return on investment

The key driver of profitability was effective summer weed control; the greater the delay in weed control, the greater the economic loss. For every dollar invested in fallow herbicides, the miss first spray treatment returned $1.90/ha, the full spray treatment returned $7.20/ha and the delayed spray treatment returned $3.90/ha (*Table 6*).

The application of nitrogen fertiliser was not profitable in any of the treatments (*Table 6*) and did not have the high returns on investment achieved from full weed control alone. Application of nitrogen fertiliser combined with the spray treatments provided a return ranging from a loss of -$1.20 to gain of $0.80/ha (*Table 6*). However, seasonal conditions would have strongly impacted N uptake (rain did not occur for 20 days after N application) and hence return (or loss) on investment. Some upfront N applied at sowing could have improved crop response to N.

Discussion

These results show that effective summer weed control is a key driver of profitability in cropping systems in central NSW.

Highest returns were achieved when full weed control was undertaken. This was due to lower rates of herbicides being applied, higher residual PAW and higher residual nitrogen, resulting in increased grain yields. Returns were negative when no summer weed control was undertaken (*Table 6*). This is consistent with results from other local experiments conducted by Haskins and McMaster in 2012.

Controlling summer weeds using either the full or delayed spray treatments allowed for the highest amount of PAW (*Table 4*). This stored moisture was then available for use by subsequent winter crops.

PAW was distributed throughout the soil profile at the beginning of the winter cropping season in both 2011 and 2012, however, the majority was located below 30 cm depth (*Figures 1* and *2*). This moisture stored at depth is highly valuable to dryland crops as it is likely to become available during the post-anthesis period when grain yield is particularly sensitive to water deficit. French and Schultz (1984) and Kirkegaard *et al.* (2007) state that additional subsoil water can achieve a marginal water use efficiency of three times the value for water use calculated on a whole season basis (20 kg/mm/ha).

In addition to increasing stored PAW, effective summer weed control significantly increased soil mineral N with the full spray treatment resulting in the highest level of mineral N (*Table 5*).

Conserving moisture through summer weed control increased mineral N by 0.56 kg N/ha for each 1 mm of stored moisture in the soil profile (*Figure 5*). Sadras *et al.* (2012) observed that the extra nitrogen conserved by controlling summer weeds is vital to capture the benefits of additional summer water, and reciprocally higher soil moisture is required to capture the benefits of additional nitrogen.

The rate and timing of herbicide spray treatments for summer weed control did not influence the level of phosphorus, potassium or sulphur within the soil profile (*Table 7*).

Canola grain yields were highest under the full spray or delayed spray treatments, and also under higher nitrogen regimes (*Figure 6*).

Summer weeds should be controlled when small and actively growing as this lowers the rate of herbicide required and increases herbicide efficacy. In addition, stored soil moisture and nitrogen has not yet been depleted by summer weed growth.

Soil moisture and nitrogen impact grain yield by influencing grain number (more tillers and more grains per head) and grain size. Consequently, the return on investment for effective summer weed control in this and other related trials conducted by Haskins and McMaster in 2012 has consistently been between $2.20 and $7.20/ha for every dollar invested.

Summer weed control has also been reported to enhance early sowing opportunities in some seasons, which could increase grain yield by a further 21–31% (*Kirkegaard and Hunt 2010*).

Table 6: 2011 Economic analysis of summer weed control and additional nitrogen fertiliser.

Spray treatment	Trt 1: fallow spray			Trt 2: fertiliser		Partial analysis[b]				Total variable costs[d]	Yield (t/ha)	Income[a] ($/ha)	Gross margin ($/ha)
	No. of sprays	Herbicide rate[e]	Cost ($/ha)	Kg N/ha[f]	Cost ($/ha)	Cost ($/ha)	Benefit ($/ha)	Return on investment[c] $/ha					
								Trt 1&2	Trt 2				
Nil spray	1	H	24	0	0	24				461	0.65	323	-138
				70	119	143	196	0.4	0.6	580	1.04	519	-61
				140	238	262	267	0.0	0.1	699	1.18	590	-109
Miss first spray	2	H, L	42	0	0	42	120	1.9		479	0.89	443	-36
				70	119	161	299	0.9	0.5	598	1.25	623	25
				140	238	280	501	0.8	-0.2	717	1.65	825	108
Complete spray	3	L, L, L	54	0	0	54	441	7.2		491	1.53	764	273
				70	119	173	500	1.9	-0.5	610	1.65	823	213
				140	238	292	767	1.6	0.4	729	2.18	1091	362
Delayed spray	3	H, H, H	72	0	0	72	352	3.9		509	1.35	675	166
				70	119	191	571	2.0	0.8	628	1.79	895	267
				140	238	310	727	1.3	-1.2	747	2.10	1050	303

Notes:

[a] Canola values at $500/t.

[b] Partial analysis in benefit and cost related to treatment change.

[c] Ratio compares the benefit of treatments over the Nil spray/Nil N fertiliser treatment.

[d] Total variable costs sourced from NSW DPI Farm Gross Margin Guide 2011 (canola, short fallow (no-till) central zone).

[e] H = High herbicide rate required ($24/ha including application); L = Lower herbicide rate required ($18/ha including application).

[f] Ezy N was the form of nitrogen applied at $1.70 per unit of N.

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Acknowledgements

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Table 7: Level of soil nutrients phosphorus, potassium and sulphur prior to sowing trials in 2011 and 2012.

Weed control treatment	Depth (cm)	2011 Soil test results			2012 Soil test results		
		P (Colwell) mg/kg	K (amm-acet) Meq/100g	S (KCl) mg/kg	P (Colwell) mg/kg	K (amm-acet) Meq/100g	S (KCl) mg/kg
Nil spray	0–10	14.3	1.3	3.0	6.3	607.3	26.6
	10–30	-	-	3.4	12.0	229.0	16.6
	30–60	-	-	7.2	6.0	165.3	11.6
	60–90	-	-	17.9	12.7	183.3	13.9
Miss first spray	0–10	29.3	1.3	3.8	5.0	635.7	10.8
	10–30	-	-	4.7	12.3	235.7	16.5
	30–60	-	-	8.4	7.0	156.0	22.4
	60–90	-	-	12.7	8.3	182.7	23.1
Complete spray	0–10	19.3	1.3	3.7	3.7	553.7	9.5
	10–30	-	-	4.7	12.3	235.7	16.5
	30–60	-	-	8.4	7.0	156.0	22.4
	60–90	-	-	12.7	8.3	182.7	23.1
Delayed spray	0–10	16.3	1.3	3.2	6.0	606.7	10.1
	10–30	-	-	4.2	12.3	275.3	14.9
	30–60	-	-	8.9	6.0	186.3	26.3
	60–90	-	-	18.5	10.7	205.7	26.1
P value	Spray treatment	0.096	0.984	0.274	0.762	0.394	0.515
	Depth	-	-	<0.001	0.002	<0.001	0.001
	Spray x depth	-	-	0.108	0.994	0.359	<0.001
LSD (P=0.05)	Spray treatment	12.6	0.3	2.06	3.238	51.680	4.907
	Depth	-	-	1.77	3.745	23.260	4.139
	Spray x depth	-	-	3.57	7.164	61.280	8.397

Impact of residual nitrogen fertiliser from previous season on wheat —Forbes 2012–13

Colin McMaster NSW DPI, Cowra and
Dr Peter Martin NSW DPI, Wagga Wagga

Introduction

The aim of the experiment was to quantify the amount of residual soil nitrogen found in 2013 that was derived from the sowing and post-sowing fertiliser treatments applied in 2012.

The 2012 season in central NSW began with a full profile of soil water following a wet summer, providing confidence to growers of high yield potential.

High canola prices and low wheat prices early in the season led to many growers allocating more N fertiliser to their canola crops in preference to wheat. Wheat crops were topdressed later in the season after prices had increased, however, very little rain fell during that period and nitrogen (N) fertiliser efficiency was consequently very low.

Trials

Local trials conducted by NSW DPI measured only 18%–25% N fertiliser recovery, which meant that 75%–82% of last year's fertiliser was unaccounted for.

Nitrogen fertiliser recovery can range from 0%–100%. Common 'rules of thumb' used in central NSW are 50% recovery from pre or at sowing N, 40%–50% when applied early tillering, 30% at stem elongation and 10%–20% when applied at head emergence. Fertiliser recovery is strongly related to the timing of following rainfall.

The low N fertiliser recovery experienced in 2012 led to questions from local growers and advisers regarding how unused nitrogen fertiliser from 2012 affected nitrogen supply in 2013.

Site details

Significant flooding occurred across the experiment site during the 2012 summer. The site dried out enough to sow EGA_Gregory wheat on 23 May but the site quickly became fully saturated following a 43 mm rainfall event only days after sowing.

No significant in-crop rainfall events occurred after August 2012.

Table 1: Forbes monthly rainfall (mm).

2012	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
	43	47	42	15	5	12	17	47
2013	**Jan**	**Feb**	**Mar**					
	42	15	5					

Key findings

- The dry spring in 2012 restricted N uptake from post sowing N, but this was not lost.
- Topdressed nitrogen at rates greater than 50 kg N/ha (applied mid-August 2012) significantly increased soil nitrogen levels in 2013.
- Residual soil nitrogen was retained within the top 30 cm of the soil profile.
- Nitrogen applied at sowing in 2012 had no significant residual benefit in 2013, presumably due to denitrification caused by waterlogging.
- Take a deep N test to assess nitrogen requirement.

Treatments

Table 2: 2012 Nitrogen fertiliser treatments.

Nitrogen rate[a] (kg N/ha)	Protocol
0	No additional N fertiliser
50	50 kg N/ha applied at sowing[b]
100	50 kg N/ha applied at sowing[b], 50 kg N/ha at GS32[c]
150	50 kg N/ha applied at sowing[b], 100 kg N/ha at GS32[c]

[a] N was applied as urea
[b] Urea applied at sowing via split fertiliser boot
[c] Urea topdressed @ GS32

Results

Note: All of the N fertiliser treatments (except the nil) had 50 kg N/ha applied at sowing, and the remaining N was applied at GS32. Refer to *Table 2* for treatments.

2012 fertiliser nitrogen recovered in grain

- Grain nitrogen yield significantly ($P<0.001$) increased from 70.3 kg N/ha to 97.5 kg N/ha with additional nitrogen fertiliser (*Table 3*).
- Apparent fertiliser recovery of nitrogen (50 kg N/ha) applied at sowing was 25% with an additional 13 kg N/ha removed by the 2012 crop (*Table 4*).
- Additional topdressed nitrogen (applied mid-season) applied at 50 kg N/ha and 100 kg N/ha increased crop uptake by 9 kg N/ha and 15 kg N/ha respectively (*Table 4*). Recovery of post sowing N (22% and 18%) was lower than N applied at sowing (*Table 4*).

2012 fertiliser nitrogen recovered in soil

- Fertiliser nitrogen significantly ($P<0.001$) increased residual soil nitrogen from 41 kg N/ha to 122 kg N/ha (*Table 3*).

Table 3: Impact of fertiliser applied in 2012 on yield, grain nitrogen yield (GNY) and 2013 soil residual N.

2012 N Rate (kg/ha)	2012 Yield (t/ha)	2012 GNY[a] (kg/ha)	2013 Soil residual N[b] (kg/ha)
0	4.38	70.3	41.3
50	4.68	82.9	43.8
100	4.77	92.1	86.7
150	4.81	97.5	122.3
P<0.05 LSD 5%	<0.001 0.13	<0.001 3.5	<0.001 5.1

[a] GNY = (yield x protein x 1.75)
[b] 2013 residual N data = soil mineral nitrogen (nitrate + ammonium) measured to 90 cm

Table 4: Apparent fertiliser recovery.

Fertiliser recovery	2012 nitrogen rate (kg N/ha)		
	50	100	150
Recovered N into grain	13	22	27
Uptake from sowing N	13	13	13
Uptake from topdressed N	N/A	9	15
Recovered N into soil	2	45	81
Residual N from sowing	2	2	2
Residual N from topdressing	N/A	43	78
Unrecovered N[a]	35	33	42
Unrecovered N from sowing	35	35	35
Unrecovered N from topdressing	N/A	−2	7

[a] Unrecovered N is the unaccounted nitrogen fertiliser that did not contribute to GNY or soil N. Nitrogen may have been lost via immobilisation (in soil organic matter) or denitrification

- Nitrogen (50 kg N/ha) applied at sowing had no significant residual benefit over the nil treatment (*Table 4*).
- Topdressed nitrogen applied at 50 kg N/ha and 100 kg N/ha increased soil nitrogen levels by 43 kg N/ha and 78 kg N/ha (*Table 4*).
- Most of the additional soil nitrogen was retained within the top 30 cm of the soil profile (*Figure 1*).

2012 fertiliser nitrogen unrecovered

The largest amount of unrecovered N occurred from nitrogen fertiliser (50 kg N/ha) applied at sowing, with 35 kg N/ha unaccounted for (*Table 4*). Much of the topdressed nitrogen applied at 50 kg N/ha and 100 kg N/ha was accounted for (recovered).

Summary

These results suggest that about 80% of topdressed nitrogen applied (mid-August) in 2012 may still have been in the soil at the start of 2013 and should be available for the 2013 growing season.

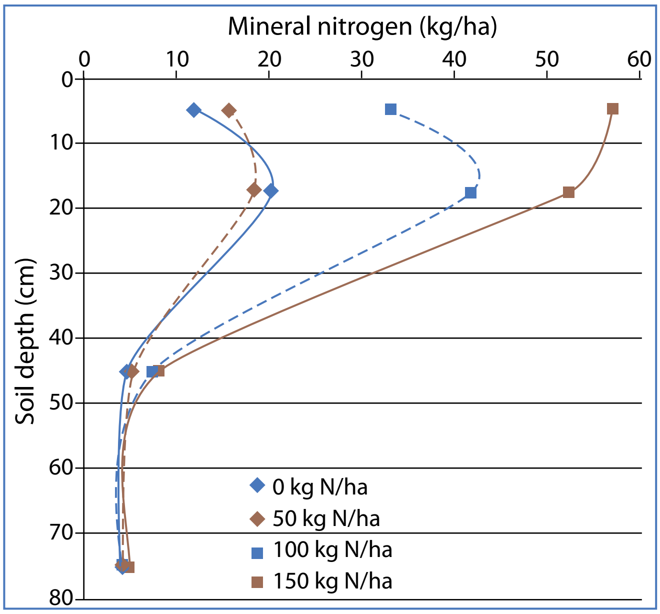

Figure 1: Distribution of residual N in the soil profile. Soil mineral nitrogen was determined by taking five soil cores per plot (1.7 m x 10 m) and bulking samples together on the 7 March 2013

Unrecovered fertiliser nitrogen from topdressing mid-season in 2012 was very low. If the nitrogen was not removed via increased grain yield, it remained within the top 30 cm of the soil profile due to a relatively dry summer without significant rainfall events.

Nitrogen not accounted for (35 kg N/ha) was far greater from nitrogen applied at sowing. This apparent loss may have been due to denitrification during extended periods of waterlogging in the 2012 winter, but a proportion of this apparent loss may also be due to immobilisation of nitrogen in the soil. The site was only just dry enough to sow and received 43 mm of rain only days after sowing. Weier *et al.* (1996) state the maximum N loss from denitrification in temperate climates is 20–30 kg N/ha during the growing period, consistent with the losses measured in this experiment. Other data suggests that denitrification rates can be as great as 2 kg N/ha per day (*Angus, 2013*).

The N balance presented in this report does not include nitrogen retained in stubble or immobilised in soil organic matter as this would require a 15N tracer.

Further reading on denitrification and an update on the low status of soil nitrogen levels across NSW in 2013 can be found on the GRDC website: www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/02/Will-low-protein-become-the-new-norm.

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Phosphate fertiliser source—Gunningbland NSW 2009 to 2012

Colin McMaster NSW DPI, Cowra

Introduction

This experiment evaluated the effectiveness, profitability and residual benefit of various phosphate fertiliser sources over a four-year period from 2009 to 2012.

Due to the combination of drought and highly volatile fertiliser prices many growers in southern NSW have started to explore the use of alternative P sources and nutritional programs.

Traditionally in southern NSW growers have banded all their granular high-analysis fertiliser at sowing with fungicide-treated seed. It is generally accepted that approximately 20%–30% of fertiliser P banded at sowing is available in the first year and the residual amount becomes available in subsequent crops (*Price, 2006*).

The exact ratio of how much P gets locked up will vary depending on soil characteristics such as soil texture, soil acidity/alkalinity and availability of aluminium, iron and calcium.

The potential of a soil to lock up P is estimated by the phosphorus buffer index (PBI). The majority of soil types in southern NSW have low PBI values indicating that much of the applied P will become plant available over time.

The combination of paddock history, crop type (root morphology and arbuscular mycorrhizal fungi), sowing date (early or late sown) and soil test results have proven to be beneficial tools in predicting individual paddock responsiveness to freshly applied fertiliser P.

Growers and advisors are now being challenged by new hypotheses that claim further fertiliser efficiencies can be gained for southern NSW.

Some biological advocates promote the use of rock phosphate products in conjunction with 'microbe-friendly' seed treatments and 'biological inoculants'. It is claimed that the improved biological health of the soil will unlock some of the tied up P and enhance the effectiveness of applied fertiliser P.

Conventional understanding of rock phosphate suggests it is only appropriate for slow-growing grass or tree crops and is only successful on acidic soils (*White, 1979*) with high rainfall (*Bolland, 2007*).

Interest in liquid P fertilisers is also developing due to the increased efficiencies of liquid P over granular P on the alkaline calcareous soils of South Australia (*McBeath, 2005*). These efficiencies are yet to be proven in the common soil types of southern NSW as the presence of topsoil limestone is not considered regionally significant.

Key findings

- High-analysis granular fertiliser (MAP) was the most profitable P source.
- Liquid forms of P performed well, but high purchase price reduced profitability.
- Rock phosphate did not improve grain yield (averaged over three years) or residual soil P.
- Additional biological inoculants applied to rock phosphate did not significantly improve response greater than MAP.
- Consider long-term implication of P fertiliser source and application rate. If P rates are reduced, the residual soil P benefit will also be reduced.
- Growing season rainfall will impact crop response to freshly applied P.
- Growers must consider fertiliser effectiveness and cost ($ per unit of P) when considering P fertiliser source.
- It was more profitable to apply no fertiliser than apply rock phosphate.

Site details

Location	35 km north-west of Forbes, central NSW
Trial design	randomised complete block (4 replicates) laid out as a single row
Soil type	grey vertosol
Colwell P	15 mg/kg
PBI	106 mg/kg
Total inorganic P	62 mg/kg
Total P	252 mg/kg
Organic P	190 mg/kg
pH_{Ca}	7.6
Free lime present	Yes[a]

[a] Free lime present within topsoil, estimated between 1%–5%.

Treatments

From 2009 to 2011 a range of phosphorus fertiliser products (*Table 2*) were applied over the same plot (1.8 m x 20 m) for three consecutive winter crop seasons. The fourth season relied on residual P, with no fertiliser P applied in 2012. The plots were sown to wheat in 2009 and 2010, canola in 2011 and wheat again in 2012.

Table 1: Rainfall data for the experiment site.

	Rainfall (mm)			
Year	2009	2010	2011	2012
Stored PAW mm[a]	84	140	202	147
In-crop rainfall	154	300	199	203
Effective rainfall	238	440	401	350

[a] Stored moisture measured at sowing via five gravimetric soil cores.

Table 2: Fertiliser source/product details.

Phosphorus source	P %	$/tonne	$/kgP
Hi-analysis MAP (granular)	22	950	4.32
Rock phosphate (granular)	12	775	6.46
Phosphoric acid (liquid)	16	2231	13.94
Polyphosphate (liquid)	23	3214	13.98

Note: basal applications of nitrogen applied as urea to balance all treatments. Fertiliser costs derived from 2009 prices.

Phosphorus rates: 0 kg P/ha, 5 kg P/ha, 10 kg P/ha and 20 kg P/ha.

An additional 'systems' experiment was conducted to evaluate the impact of 'microbe-friendly' seed treatments, 'biological' inoculants and rock phosphate fertiliser (*Table 3*).

Results

Refer to *Tables 4* and *5* for wheat and canola grain yield and gross margin results for individual years from 2009–12.

Grain yield response

On average, grain yield was significantly affected by fertiliser source (P<0.001) and rate (P=0.001). The average combined grain yield over the three-year period was 2.65 t/ha. The highest average yield of 3 t/ha was achieved by MAP at 20 kg P/ha (*Figure 1*).

Grain yield responded positively with increasing application of MAP and both forms of liquid (Ezy NP and Polyphos) with similar response curves (*Figure 1*). For example, the MAP fertiliser treatment at 5 kg, 10 kg and 20 kg P/ha increased grain yield on average by 0.33 t/ha, 0.47 t/ha and 0.63 t/ha respectively.

There was no significant yield benefit of rock phosphate fertiliser when averaged across three years. However, in one season (2011) the 10 kg P/ha and 20 kg P/ha rates did significantly increase yield by 0.35 t/ha and 0.49 t/ha over the nil P treatment (*Table 4*). This grain yield benefit was not carried over into the following year (2012).

The addition of biological inoculants (*Table 3*) did not improve the rock phosphate response greater than MAP in this experiment (*Figure 2*).

Table 4 illustrates the impact of seasonal conditions on P response. Grain yield at the high P rate responded by 0% in 2009 (drought year), 22% in 2010 (high in-crop

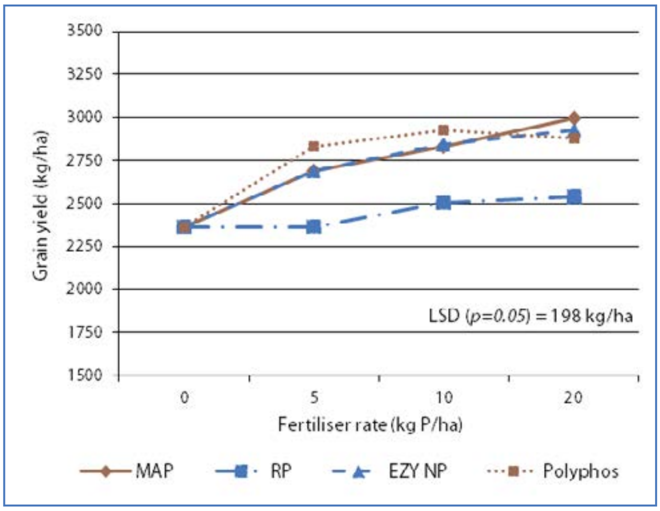

Figure 1: Averaged grain yield response of fertiliser treatments over a three-year period.

Table 3: Additional products used in 'systems' experiment.

Fertiliser treatment	Additional product applied	Application details			Key aim of product
		Seed or foliar	Rate	Cost $/ha	
Rock phosphate	Broad-spectrum inoculum of compost microbes	seed	5 L/t	0.91	Re-inoculate rhizosphere with a broad-spectrum inoculum to improve the soil's natural organic cycle with beneficial fungi and bacteria
	Broad-spectrum inoculum of compost microbes	foliar	5 L/ha	18.49	Re-inoculate the phyllosphere (leaf surface) with a broad-spectrum inoculum to maximise flower bloom, flower retention and harvest yield
Hi-analysis granular (MAP)	Raxil	seed	1 L/ha	1.58	Control bunts and smuts

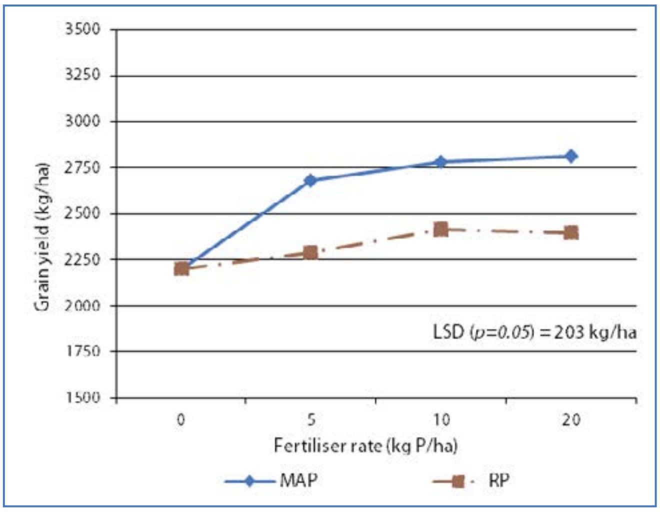

Figure 2: Averaged grain yield response over the three-year period comparing MAP with rock phosphate + biological inoculants.

rainfall), 72% in 2011 (average in-crop rainfall) and 14% in 2012 (no P applied to any treatment in 2012).

Residual P build-up

Residual P benefit was measured by soil testing after two crops, following the 2010 wheat crop (*Figure 3*) and also by measuring grain yield in 2012 (*Table 4*) as no fertiliser P was applied to that wheat crop.

Residual soil P (Colwell)

- Residual soil P levels ranged from 14.7 mg/kg to 22.7 mg/kg and differed significantly with fertiliser source (P<0.001), rate (P<0.001) and interaction between fertiliser source and rate (P=0.02).
- The greatest residual benefit was from the high P rate (20 kg P/ha) of Polyphos and MAP, with a respective increase of 7.9 mg/kg and 6.2 mg/kg over the nil P treatment (*Figure 3*).
- Residual P levels following MAP application increased as the rate increased. The 5 kg P/ha, 10 kg P/ha and 20 kg P/ha treatments increased residual P levels by 1.8 mg/kg, 2.6 mg/kg and 6.2 mg/kg respectively.
- Rock phosphate did not increase soil P levels.
- Both liquids (Ezy NP and Polyphos) had residual responses similar to the MAP treatment. However, Polyphos (20 kg P/ha) did have a significant (P<0.001) residual benefit of 3.3 mg/kg over the 20 kg P/ha Ezy NP treatment (*Figure 3*).

Residual grain yield (2012)

- The 2012 grain yield was significantly affected by the fertiliser source (P<0.001) and rate (P<0.001) for the previous three seasons.
- The highest grain yield in 2012 was achieved where MAP was applied at 20 kg P/ha for the previous three seasons. The yield was 0.57 t/ha higher than the nil P treatment.

Table 4: Grain yield and Colwell P soil test results.

Fertiliser treatment kg P/ha	Wheat yield 2009 (t/ha)	Wheat yield 2010			Canola yield 2011			Wheat yield 2012			Colwell P 2011		
		(t/ha)	(% Nil P)		(t/ha)	(% Nil P)		(t/ha)	(% Nil P)		(mg/kg)	(% Nil P)	
Nil P	1.65 a	4.15	100	a	1.38	100	a	4.22	100	a	14.7	100	a b
MAP 5	1.43 a	4.56	110	b c	2.03	147	c d e f	4.57	108	c d e	16.5	112	b c d
MAP 10	1.52 a	4.72	114	b c d	2.18	158	e f g	4.54	107	b c d	17.3	118	c d e
MAP 20	1.50 a	5.06	122	d	2.37	172	g	4.80	114	e	20.9	142	f g
RP 5	1.53 a	3.99	96	a	1.56	113	a b	4.15	98	a	15.5	105	a b c
RP 10	1.64 a	4.09	99	a	1.73	125	b c	4.31	102	a b	13.4	91	a
RP 20	1.58 a	4.17	100	a	1.87	136	c d	4.21	100	a	15.0	102	a b
Ezy NP 5	1.681 a	4.33	104	a b	2.04	148	d e	4.20	99	a	15.9	108	b c d
Ezy NP 10	1.608 a	4.60	111	b c	2.30	167	e f g	4.32	102	a b c	17.5	119	c d e
Ezy NP 20	1.551 a	4.85	117	c d	2.35	170	f g	4.63	110	d e	19.3	131	e f
Polyphos 5	1.72 a	4.58	110	b c	2.20	159	e f g	4.34	103	a b c	18.1	123	d e
Polyphos 10	1.67 a	4.75	114	c d	2.32	168	e f g	4.61	109	d e	18.9	129	e f
Polyphos 20	1.52 a	4.79	115	c d	2.32	169	f g	4.58	108	d e	22.6	154	g
CV	14%	5.8%			8.9%			3.8%			9.4%		
LSD (P=0.05)	0.32	0.40			0.29			0.25			2.3		

Notes:
* All seed was treated with either Raxil on wheat or Jockey + Gaucho on canola.
* No fertiliser was applied in the 2012 wheat experiment to measure impact of residual P.
* Values that do not have the same letter within a column are significantly different at LSD (P=0.05).

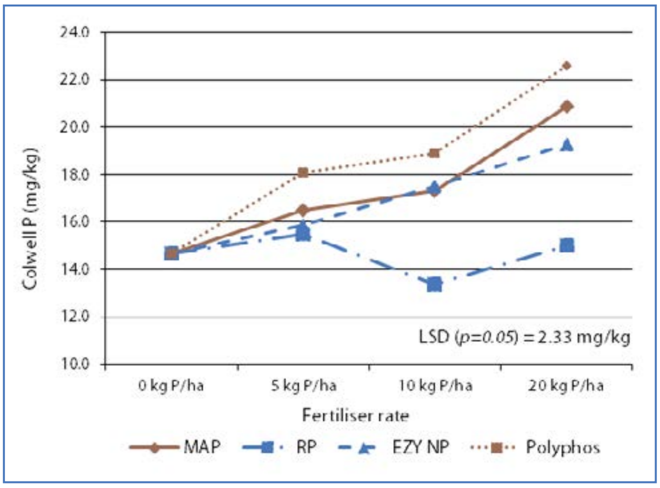

Figure 3: Residual soil phosphorus after the first two wheat crops.

- The 5 kg P/ha, 10 kg P/ha and 20 kg P/ha rates of MAP produced a yield benefit of 0.35 t/ha, 0.31 t/ha and 0.57 t/ha respectively over the nil P treatment.
- There was no significant yield benefit (above nil P) in 2012 where rock phosphate had been applied in the previous three seasons.
- Both liquid products produced similar yield responses to MAP fertiliser. However, Ezy NP at 5 kg P/ha did produce a yield reduction of 0.37 t/ha when compared with MAP at 5 kg P/ha, and a 0.14 t/ha yield reduction when compared with Polyphos.

Profitability

- Profitability was affected by fertiliser source and application rate, and ranged from –$182 to $519/ha (*Figure 4*).
- Cost ($/kg P) of the various fertiliser sources were $4.32 kg/P for MAP, $6.46 kg/P for rock phosphate, $13.94 kg/P for Ezy NP and $13.98 kg/P for Polyphos (*Table 2*).
- The most profitable treatment over the four-year period was 20 kg P/ha of MAP, with a total benefit of $519/ha over the nil P treatment.
- MAP produced a positive economic return across all three rates and grain yield increased as fertiliser rate increased. The 5 kg P/ha, 10 kg P/ha and 20 kg P/ha rates increased profitability (over three years) by $380/ha, $430/ha and $510/ha respectively.
- Rock phosphate treatments produced a negative economic return across all three rates. The 5 kg P/ha, 10 kg P/ha and 20 kg P/ha rates reduced profitability by –$81/ha, –$14/ha and –$156/ha respectively. It was more profitable to apply no fertiliser than to apply rock phosphate.
- Both forms of liquid phosphate (Ezy NP and Polyphos) produced a positive economic return at the lower rates of 5 kg P/ha and 10 kg P/ha and a negative economic return at the higher rate of 20 kg P/ha (–$140/ha and –$182/ha respectively).
- Polyphosphate was more profitable at 5 kg P/ha and 10 kg P/ha than Ezy NP, with a benefit of $166/ha and $114/ha above Ezy NP.

Table 5: Gross margin analysis for fertiliser treatments.

Fertiliser type and rate kg P/ha	Gross margin ($/ha)					Benefit over Nil P ($/ha)
	Year 1 Wheat	Year 2 Wheat	Year 3 Canola	Year 4 Wheat	Total	
Nil P	90	591	319	732	1732	
MAP 5	25	651	622	811	2109	378
MAP 10	21	661	674	803	2160	428
MAP 20	–26	685	728	864	2251	519
RP 5	34	526	376	714	1651	–81
RP 10	23	514	428	752	1717	–14
RP 20	–54	464	437	729	1576	–156
Ezy NP 5	27	557	581	726	1890	159
Ezy NP 10	–58	540	643	754	1879	148
Ezy NP 20	–209	451	524	824	1591	–140
Polyphos 5	35	606	658	758	2057	325
Polyphos 10	–46	571	648	821	1993	262
Polyphos 20	–215	438	513	814	1550	–182

Notes:
Variable costs (not including fertiliser) used for 2009 wheat = $240/ha, 2010 wheat = $240/ha, 2011 canola = $370/ha and 2012 wheat = $240/ha.
Refer to Table 1 for various fertiliser costs.
Grain price received for 2009 wheat = $200/t, 2010 wheat = $200/t, 2011 canola = $500/t and 2012 wheat = $230/t.

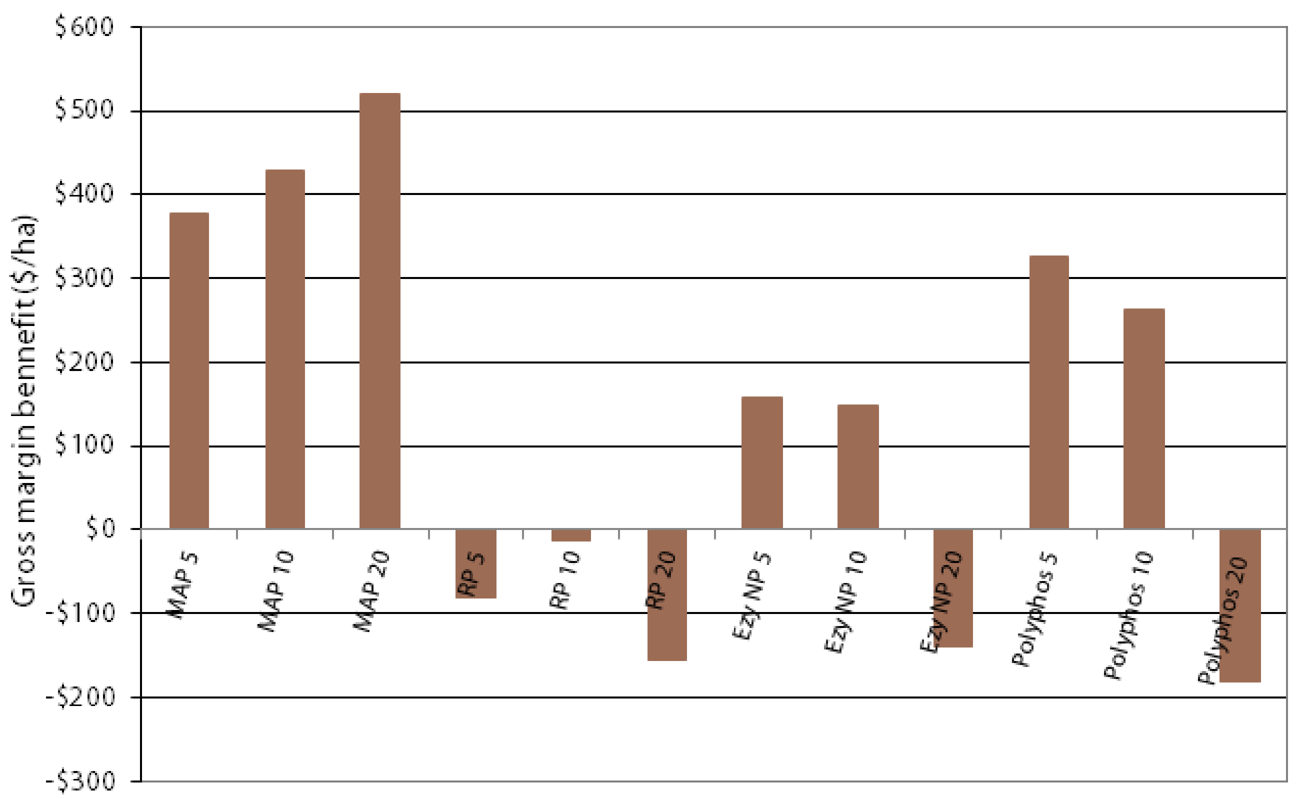

Figure 4: Gross margin benefit ($/ha) of fertiliser treatments over the nil P treatment over four years.

These results do not consider the additional cost associated to convert machinery for liquid P application, or the additional freight cost required for less concentrated P sources. For example, rock phosphate would need approximately twice the quantity of product to provide the same quantity of P as MAP.

Summary

These results highlight a number of important factors to consider when making phosphate fertiliser decisions.

1. Phosphate fertiliser selection

Growers must consider cost per kg of P compared with cost per tonne of product as this greatly influenced profitability in this experiment. MAP and both forms of liquids had similar response curves; however, MAP was significantly more profitable due to lower cost per unit of P.

The fertiliser source needs to become plant available to be effective. These results indicate that high-analysis granular fertiliser and both forms of liquid P respond positively and similarly, whilst rock phosphate was unresponsive and not available for plant uptake. Therefore, rock phosphate fertiliser was both ineffective and expensive in the four years that it was evaluated in this experiment. The addition of biological inoculants did not improve rock phosphate response greater than MAP in this experiment.

Another consideration is the relationship between freight costs and P concentration within a fertiliser. For example, MAP fertiliser contains 22% P and will therefore require less tonnes/freight cost than rock phosphate that contains 12% P.

2. Long-term implications

Fertiliser source and rate would have had an impact on the 2013 season as well as future years.

An advantage of purchasing cheap and effective P is that you can buy more P for the same dollar value, which allows greater flexibility in future years. As residual P increases, rates can safely be reduced with knowledge of the local P calibration curve.

Residual P benefit will decline if fertiliser rates are reduced to allow for more expensive forms of P to be used (i.e. liquids). If crop removal of P is greater than fertiliser P input, soil P will decline until crop P removal is equal to the rate of mineralisation of organic P.

Rock phosphate did not have any residual benefit in either soil P (Colwell) or grain yield (2012) at the 5 kg P/ha, 10 kg P/ha or 20 kg P/ha rates.

3. Seasonal factors and P response

The combination of a soil test result, local P calibration curve, paddock and crop rotation history and sowing date can greatly assist in determining paddock responsiveness to additional fertiliser P.

As demonstrated by this experiment, seasonal factors will influence crop response to freshly applied P. Other studies in South Australia have demonstrated that P uptake is largely from residual soil P in wetter years (crop roots can forage in nutrient-rich topsoil), and from freshly applied P in average seasons. Therefore, the response from freshly applied P will vary from year to year.

Whilst we cannot control the season, we can control how much we invest in the crop. Selecting the appropriate fertiliser source will allow yield to be maximised when seasons allow, and reduce risk when seasonal factors produce low yields. In this experiment, the high-analysis granular fertiliser MAP maximised yield potential whilst also requiring the lowest breakeven yield to cover fertiliser cost, hence reducing financial risk in low-yielding seasons.

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Residual effects of a pulse crop phase in the farming system

Dr Eric Armstrong, Luke Gaynor, Gerard O'Connor, Dr Sarah Ellis and Dr Neil Coombes NSW DPI, Wagga Wagga

Key findings

- Pulse crops offer significant advantages to following wheat crops in southern NSW.
- Brown manuring offered no yield advantage for the following crop over harvesting pulses for grain.
- Choose the pulse crop best suited to your soils, environment and system.

Introduction

Many of the benefits of pulse crops in farming systems are the advantages to following crops. Improved weed control, reduced cereal disease, greater available stored soil water and increased soil nitrogen are among the potential benefits.

Treatments

Two wheat trials were conducted in 2014 to measure residual effects of pulse treatments on wheat yield and protein. The paddock history of the two trials is:

1. In 2012 a brown manure experiment compared three times of sowing (TOS) of six legume crops that were either brown manured or harvested for grain. Brown manuring was carried out relatively early at anthesis of black oats. This was followed with a wheat crop in 2013 which suffered severe frosting. The aim of the 2014 experiment was to determine if pulses were still influencing the system two years on.
2. In 2013 a brown manure experiment compared three TOS of seven legumes and a wheat crop that was either brown manured or harvested for grain. Brown manuring was again carried out relatively early at anthesis of black oats.

Normal agronomic practice was followed for sowing, weed control and harvest. Wheat (cv. Lancer) was then sown across these trials in 2014 using accepted agronomic practice.

Results

Wheat 2014 post brown manure 2013

The wheat (cv.Lancer) sown on wheat that was harvested in 2013 for grain yielded 2.8 t/ha in 2014 (*Table 1*). This was lower yielding than wheat after all pulses that were harvested for grain in 2013 (average 3.3 t/ha). There were no significant differences between wheat yields after any of the brown manure treatments and TOS in 2013, including the cereal (average 3.4 t/ha). However the dry spring in 2014 is likely to have capped the yield potential and minimised the expression of any treatment effects.

The main rotation effect was seen in wheat grain protein. The grain protein of wheat after wheat was well below 10% (*Table 1*) and would generally incur a substantial marketing penalty or unfavourable price spread. Manuring the previous crop led to a significant increase in grain protein of 1.0 to 1.5% compared to that harvested for grain, but this is unlikely to negate the opportunity cost of manuring the previous crop for yield and protein gains alone.

From these studies and previous work, brown manuring should be used when weed resistance is the major driver. The potential moisture conservation and residual nitrogen for the following crop is an added bonus. The key message from this research was there were no significant differences between wheat yields following any of the legume treatments that were brown manured or harvested for grain (*Table 1*). This suggests that growers should maximise their rotation gross margin by taking their pulse crops through to harvest

Table 1: Wheat grain yield and protein after brown manure crops in 2013.

2013			Wheat yield 2014 (t/ha)		Protein (%)		Wheat grade	
Crop	**Variety**	**Grain yield (t/ha)**	**Grain**	**Manure**	**Grain**	**Manure**	**Grain**	**Manure**
Faba bean	Fiord	2.15	3.35	3.46	10.3	11.7	ASW	H2
Lupin	Mandelup	1.46	3.34	3.30	10.9	12.5	APW	H2
	Rosetta	1.52	3.30	3.46	11.1	12.6	APW	H2
Vetch	Morava	1.17	3.35	3.34	11.2	12.5	APW	H2
Field pea	Morgan	1.56	3.33	3.46	10.8	11.9	APW	H2
	PBA Percy	2.03	3.25	3.45	11.2	12.2	APW	H2
	PBA Hayman	0.61	3.38	3.37	11.5	12.0	APW	H2
Wheat	Lancer	2.84	2.89	3.31	8.7	9.6	ASW	ASW
LSD		0.18	0.25		0.5			

and selling the grain. However, the higher protein following brown manured crops indicates that these treatments may have attained a higher yield if spring rainfall had been more favourable.

Wheat 2014 following wheat 2013 and brown manure 2012

Two years after brown manuring there were still benefits evident in the system. Wheat sown two years after a brown manuring experiment averaged 3.5 t/ha (*Table 2*). There was no difference between crops brown manured or harvested for grain, and only a small decrease in yield for wheat grown two years after Mandelup lupins compared to Morava vetch, Hayman and Percy field peas.

However there remained treatment effects with more protein (about 0.5%) in the wheat following pulse crops that had been brown manured (12.6%) instead of harvested for grain (12.0%). There were also differences between species (*Table 2*), with most wheat grain protein following Morava vetch and Percy field pea, and the least protein percentage following the lupin crops. This may reflect the biomass of the preceding legumes.

Summary

Growing any of the pulse crops adapted to southern NSW can have significant advantages on subsequent wheat yields in the first and second year compared to growing wheat on wheat.

Brown manuring may be a useful tool to combat herbicide resistance but did not increase subsequent wheat grain yields in this experiment.

Brown manuring had no yield advantage over harvesting pulses. However there were significant wheat protein benefits to crops following brown manuring.

There were no yield differences detected between any of the varieties of pulses that were brown manured although there were small protein differences. Therefore for brown manuring, choose the pulse crop suited best to your area, environment and system.

Acknowledgements

This experiment is part of the *National pulse program* (DAV00113, 2013–2016) jointly funded by GRDC and NSW DPI.

Thanks to Mr Jon Evans for technical assistance.

Table 2: Grain yield and protein of wheat in 2014 after wheat in 2013 and a brown manure experiment in 2012.

2012 Crop	Variety	2014 wheat grain yield (t/ha)	Grain protein (%)
Lupin	Rosetta	3.46	11.7
	Mandelup	3.35	11.9
Field pea	Morgan	3.48	12.3
	Hayman	3.68	12.4
	Percy	3.64	12.7
Vetch	Morava	3.65	12.7
	LSD	0.22	0.4

Effect of inoculant formula and soil moisture condition on pulse nodulation on an acidic red-brown earth—Wagga Wagga 2013

Dr Eric Armstrong, Eric Koetz, Luke Gaynor and Gerard O'Connor NSW DPI, Wagga Wagga

Introduction

The impact of pulses as a break crop and as a net contributor of biologically fixed N across all farming systems of Australia is highly dependent on effective nodulation.

Pulses, particularly chickpea, field pea, lentil and faba bean, have evolved from world centres dominated by alkaline soils, similar to many environments in South Australia, Victoria and northern NSW. Similarly, rhizobia are adapted to alkaline soils and survive for many years in these regions without the need to routinely inoculate. However, this situation is somewhat different in southern NSW where farming systems are dominated by acidic red-brown earths where rhizobia do not survive. Effective inoculation on these acidic red-brown earths is essential to achieve maximum nitrogen fixation and residual nitrogen benefits for these crops. Effective nodulation is dependent on the presence of an appropriate rhizobia strain or group, formulation of the inoculant, pulse species, soil moisture conditions at sowing and previous cropping history.

Since dry autumns have become increasingly common over the past decade, growers are questioning the effectiveness of inoculating pulses using traditional methods under dry sowing conditions. Given this background, we undertook a study to assess nodulation of field pea, chickpea, faba bean and lentil using different inoculant formulations on a dry or wet acidic red-brown earth at Wagga Wagga in southern NSW in 2013.

Experiment details

Location	Wagga Wagga Agricultural Institute, Paddock 9A3
Fertiliser	80 kg/ha grain legume super (0:15:7) at sowing
Seeding rates	target plants/m^2: field pea 45, chickpea 40, faba bean 28, lentil 120
Row spacing	30 cm into burnt stubble
Herbicides	pre-sowing tank mix of glyphosate (1.5 L/ha) + Terbyne (1 kg/ha) + Stomp (2 L/ha) and Avadex (2 L/ha)

Well below average summer and autumn rainfall preceded this experiment which resulted in low soil moisture profiles and a dry seedbed for sowing. Growing season rainfall (April–October) was 24% below average and maximum and minimum temperatures were 2.1°C and 1.4°C above long-term average temperatures respectively.

Despite these dry and unseasonably warm conditions, pulses grew disease-free and yielded relatively well. Extreme frost events occurred in mid-October resulting in mild to severe frost damage (up to 20% of pods).

Key findings

- Field pea, faba bean, chickpea and lentil must be routinely inoculated to ensure effective nodulation on acidic red-brown earths in southern NSW.
- Granular and peat-based (as water injected) inoculants were equally effective in nodulating field pea, chickpea, faba bean and lentil.
- Nodulation was equally effective when sowing either into a dry or wet soil at Wagga Wagga in 2013.
- Nodulation was poorest in lentil.

Treatments

Pulses	PBA Oura field pea, PBA Slasher chickpea, PBA Farah faba bean, and CIPAL0901 lentil
Sowing dates	9 May 2013 (dry soil) and 7 June 2013 (moist soil)
Inoculants	Three formulations: granular (Becker and Underwood), liquid (peat slurry into row) and nil were used for each rhizobia group. Rhizobia groups: E for field pea and lentil, N for chickpea, and F for faba bean.

Methods

Two sowing dates were selected to reflect different soil moisture conditions: early (9 May 2013) into a dry seed bed (following a very dry summer receiving no effective rainfall) and late (7 June 2013) into a moist seed bed. At each sowing, the un-inoculated control was sown first in an effort to prevent any residual contamination from the other formulations. The liquid-based formulation then followed, made by mixing a peat-based product with water then injecting through micro-tubes directly into the furrow just behind the seed at sowing. Finally, the granular-based formulation was sown with the seed through the cone seeder. While rhizobia were inoculated into a very dry soil at the first sowing, they did receive 29 mm of rain five to eight days later.

Crucial events affecting the survival of rhizobia and effectiveness of nodulation of each pulse in this experiment were:

- varying levels of soil moisture at sowing

- subsequent rainfall
- the different formulations of inoculant, and
- the acidic nature of our local soils (a red-brown earth, *Table 1*).

Only one variety of each of the main pulses was chosen (see Treatments above). The experiment was replicated three times and managed according to best practices for the region.

Table 1: Soil chemical analysis, Wagga Wagga 2013.

Depth cm	0–10	10–20
pH_{Ca}	4.6	4.3
Al Sat (%)	2.5	9.7
Nitrate N	11	8.3
Ammonium N	1.5	0.8
P (Colwell)	38	11
CEC	5.62	5.35

Nodule scores

Ten plants with intact roots to 20 cm were dug up and collected from each plot eight weeks after emergence to assess nodulation. Plants were soaked in water then soil removed to assist assessment. Nodule ratings were conducted using a scoring system developed by Corbin *et al.* (1977), (*Table 2*). Scores of 0–1 are inadequate and reflect very low nodule numbers, scores of 2–3 are adequate, and scores of 4–5 are high and show excellent nodulation.

Table 2: Nodule classification ratings used at Wagga Wagga in 2013 (Corbin *et al.* 1977).

Nodule score	Nodule number on crown	Nodule number on laterals
0.0	0	0
0.5	0	1–4
1.0	0	5–9
1.5	0	>10
2.0	few	0
2.5	few	few
3.0	many	0
4.0	many	few
5.0	many	many

Results

1. Nodulation

Nodule scores for all pulses are presented in *Figure 1*. The main findings included:

- Without inoculation, pulses did not effectively nodulate. This reflects the acidic nature of the soils in this environment, particularly from 10 to 20 cm.
- There was very little difference in effectiveness of the two inoculant formulations under review.
- Nodulation was equally effective with dry or moist soil sowing. Rhizobia survival and nodulation on the dry soil treatments was assisted by 29 mm rain falling 5–8 days after sowing.
- Nodulation was poorest in lentil, possibly reflecting its greater sensitivity to acidic soils.

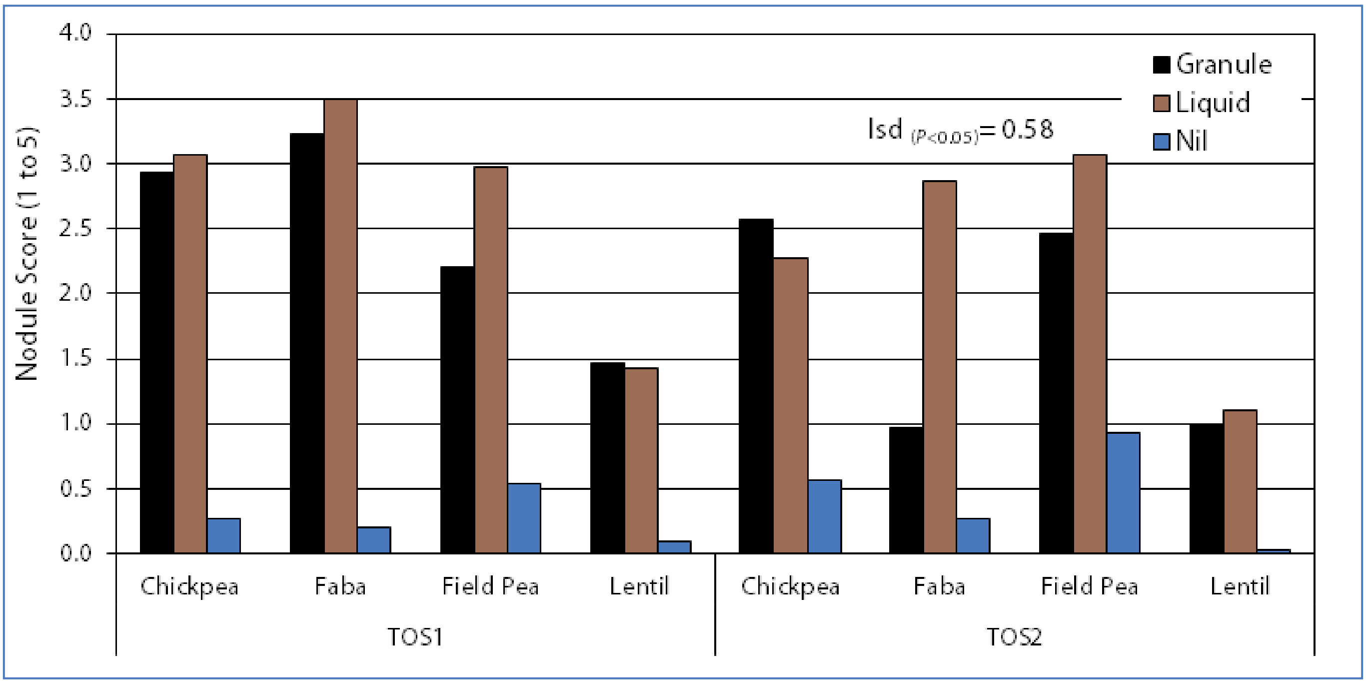

Figure 1: Nodule scores resulting from sowing chickpea, faba bean, field pea and lentil into dry or wet soils using different inoculant formulations at Wagga Wagga, NSW, 2013.

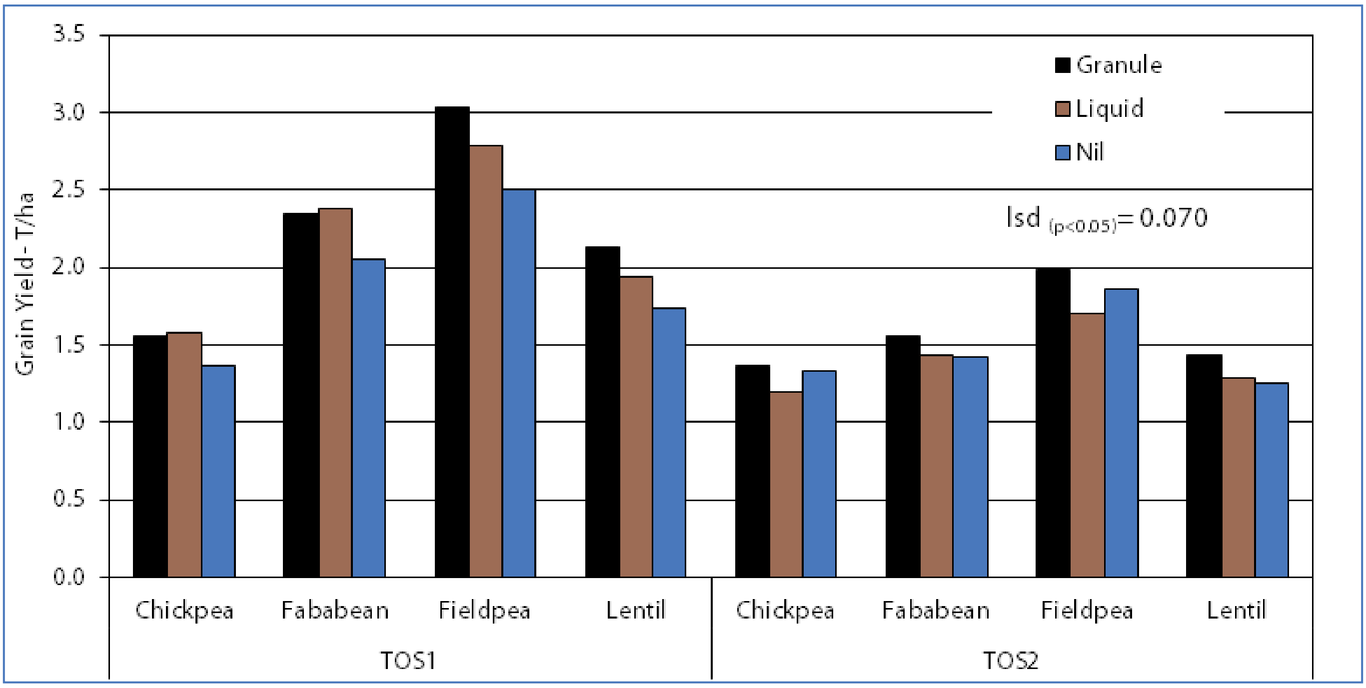

Figure 2: Grain yields resulting from sowing chickpea, faba bean, field pea and lentil into dry or wet soils using different inoculant formulations at Wagga Wagga, NSW, 2013.

2. Grain Yield

- Un-inoculated pulses had very low nodule numbers but still managed to grow with only minimal above ground biomass differences in colour and height throughout the season. Yield of un-inoculated plots was significantly lower only at the first sowing. However, nitrogen fixation and residual N benefits should better reflect the poor nodulation observed; samples are currently being tested for N and N_2 fixation.
- Inoculant formulation had no significant effect on yield at both sowings. This suggests granular or peat formulations (as water injected) were equally effective with these four pulses under either dry or moist soil conditions at Wagga Wagga in 2013.
- Grain yield was reduced by an average 30% when sowing was delayed from 9 May to 7 June. Field pea was the highest yielding pulse.

References

Corbin, E.J., Brockwell, J. and Gault, R.R. (1977) 'Nodulation studies on chickpea (*Cicer arietinum*)', Australian *Journal of Experimental Agriculture and Animal Husbandry*, vol. 17, pp. 126–134.

Acknowledgements

This experiment is part of the *National pulse program* (DAV00113, 2013–2016) jointly funded by GRDC and NSW DPI.

Thanks to Jon Evans, Technical Assistant, for assistance with experiment management and field assessments.

Effect of fertiliser application and row spacing on grain yield of lupins—Merriwagga 2013

Barry Haskins AgGrow Agronomy and Research, Dr Peter Martin and Karl Moore NSW DPI, Wagga Wagga

Key findings

- Albus lupin varieties were higher yielding than angustifolius lupin varieties.
- The application of 60 kg/ha of Superfect resulted in a significant grain yield increase for two of the three angustifolius lupin varieties but it had no effect on grain yield of Albus lupin varieties.
- Kiev Mutant and Rosetta had significantly lower grain yield at the 75 cm row spacing than the 50 cm row spacing. Row spacing had no effect on the other four varieties.

Introduction

Previous trials at Merriwagga and Wagga Wagga have shown reduced establishment in lupins following the application of starter fertiliser. This reduction in establishment has been more pronounced at wider row spacings due to the crowding effect of seeds and increased concentration of fertiliser in the seeding row (seed and fertiliser were sown apart).

The aim of this experiment was to measure the effect of fertiliser application and row spacing on establishment and grain yield of six lupin varieties (three Albus and three angustifolius).

Site details

Soil type	red sandy loam
Available N	96.6 kg/ha (0–90 cm)
Previous crop	wheat (2012 and 2011)
Sowing date	29 April 2013
Soil moisture	approximately 40 cm of moist soil
In-crop rainfall	186.5 mm
Starter fertiliser	60 kg/ha Superfect
Harvest date	7 November 2013

Treatments

6 lupin varieties	Albus: Rosetta, Kiev Mutant and Luxor Angustifolius: Jenabillup, Mandelup and WALAN2333
3 row spacings	25 cm, 50 cm and 75 cm
2 fertiliser rates	0 and 60 kg/ha Granulock 15

Results

Establishment

Lupin establishment was significantly ($P<0.001$) higher at the 25 cm row spacing (52 plants/m^2) compared to the 50 cm row spacing (39 plants/m^2) and the 75 cm row spacing (33 plants/m^2) despite the same sowing rate. The application of 60 kg/ha Superfect resulted in a significant reduction in establishment at the 25 cm row spacing (55 plants/m^2 without fertiliser and 49 plants/m^2 with fertiliser added), but had no significant effect at the 50 cm and 75 cm row spacings.

Grain yield

The Albus lupin varieties were significantly ($P<0.001$) higher yielding than the angustifolius lupin varieties (*Figure 1*).

There was a significant ($p=0.017$) interaction between variety and row spacing. The Albus lupin varieties Kiev Mutant and Rosetta had significantly lower grain yield at the 75 cm row spacing than the 50 cm row spacing whilst Luxor showed no significant yield decline with wider spacing. There was no effect of row spacing on the other varieties (*Figure 2*).

There was a significant interaction ($p=0.049$) between variety and fertiliser application. Jenabillup and WALAN2333 both had increased grain yield as a result of the application of fertiliser; however, there was no statistical effect of fertiliser on the grain yield of Mandelup or the Albus varieties (*Figure 3*).

Summary

In past trials, the application of fertiliser to lupins has generally resulted in a reduction in establishment, however, this experiment showed only a small negative effect at the 25 cm row spacing. This suggests other factors such as soil moisture, rainfall and soil type, may be interacting with the treatments from year to year.

Kiev Mutant, Luxor and Rosetta were higher yielding in this experiment. These Albus varieties were more vigorous and may have tapped into deeper soil moisture. They also matured later than the angustifolius varieties, which allowed them to benefit from the rain that fell in September. There is a general trend for Albus lupins to yield higher than angustifolius lupins at this site over previous seasons. Mandelup performed unexpectedly poorly, which may be due to it flowering earlier than the other varieties in a period of frost and moisture stress in August.

There was a positive response to fertiliser application for two of the three angustifolius lupin varieties. This response to fertiliser application had not been observed in other similar VSAP trials. More commonly in other trials, fertiliser has had no positive impact on yield across all varieties.

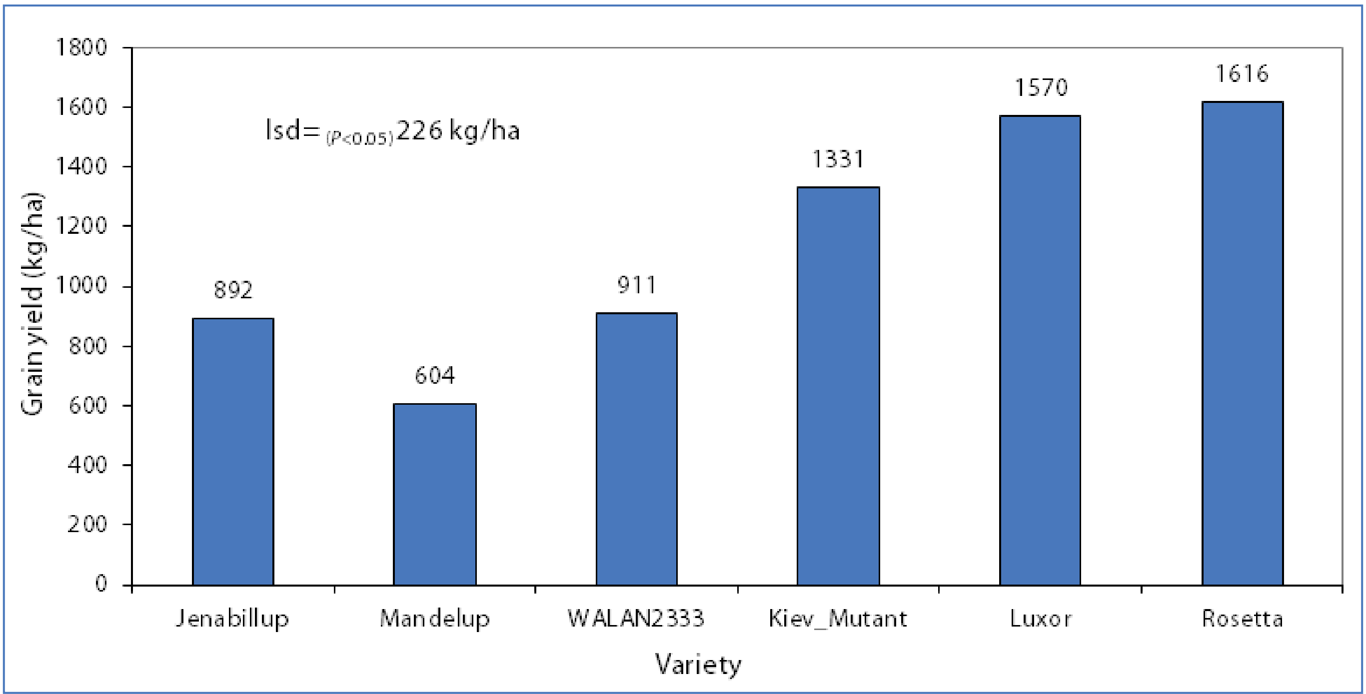

Figure 1: Grain yield of six lupin varieties averaged across three row spacings and two fertiliser treatments at Merriwagga 2013.

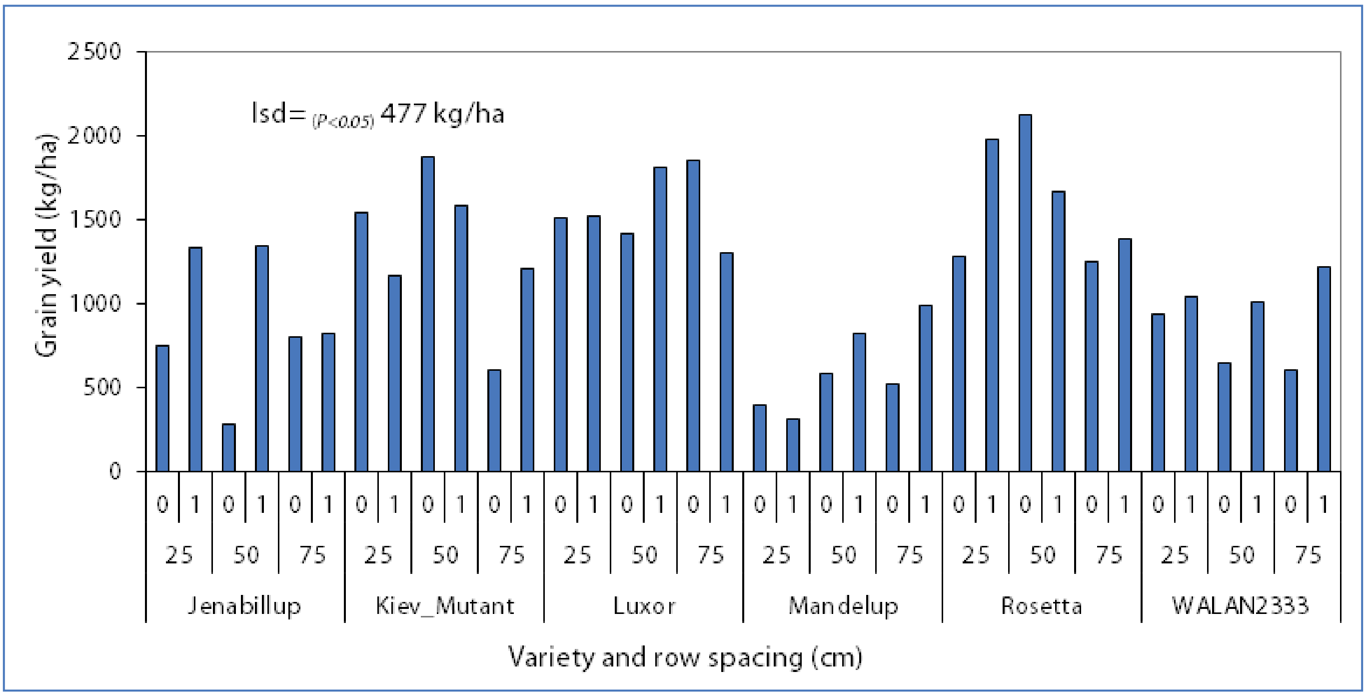

Figure 2: Grain yield of lupin variety and row spacing interactions averaged across all fertiliser treatments at Merriwagga 2013 (0=nil treatment, 1=60 kg/ha Granulock 15 applied).

Acknowledgements

This experiment is part of the *Variety specific agronomy package* project (DAN00129, 2009–2012), jointly funded by GRDC and NSW DPI, conducted by AgGrow Agronomy.

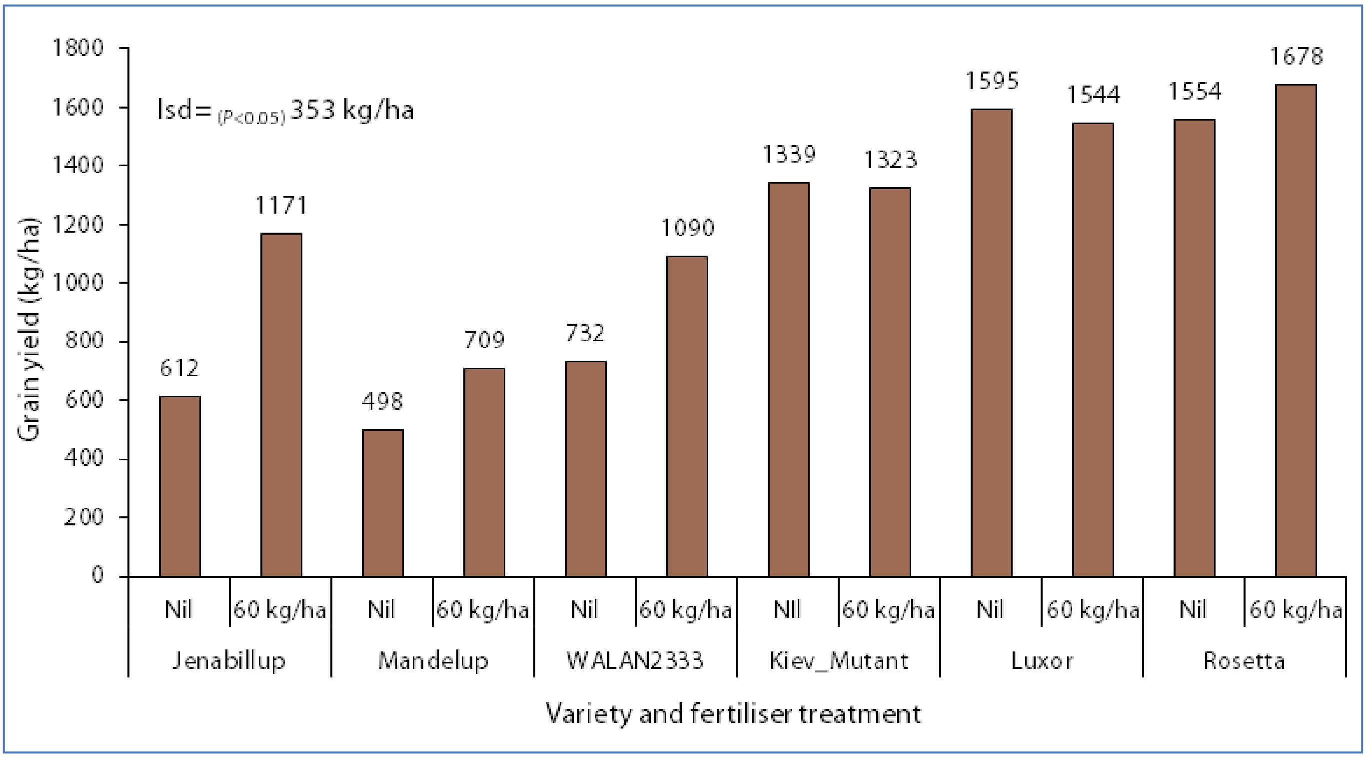

Figure 3: Grain yield of lupin variety and fertiliser interactions averaged across all row spacings in an experiment at Merriwagga 2013.

Narrow-leaf lupin breeding for Australia—southern NSW 2013 and 2014

Mark Richards, Dr Eric Armstrong, Oliver Owen and Scott Clark, NSW DPI, Wagga Wagga

Key findings

- A new variety named PBA Barlock (coded WALAN 2325) was developed by the National Lupin Breeding Program and released in WA in 2014.
- It is resistant to anthracnose and tolerant to metribuzin herbicide.
- Yielding similar to Mandelup, it has good lodging resistance and moderate phomopsis resistance.
- It is shorter in height than Mandelup with slightly later flowering and maturity.
- It has improved resistance to pod shattering over Mandelup.
- Seed is available to NSW growers through Seednet.

Introduction

The aim of this research is to evaluate, identify and release superior breeding lines of narrow-leaf lupin for south-eastern production regions of Australia. This project is the eastern node of the national lupin breeding for Australia project, led by Dr Jonathon Clements of the Department of Agriculture and Food, Western Australia.

Treatments

This project requires the annual importation of 150 to 250 Stage 2 breeding lines from the WA breeding program. The germplasm is bulked up under quarantine (specifically anthracnose) at Yanco Agricultural Institute for distribution and evaluation in NSW, SA and Vic., in subsequent years.

In NSW selected lines are promoted to Stage 3 testing at Cowra, Cootamundra, Brocklesby and Wagga Wagga for evaluation before entering National Variety Trial (NVT) testing across southern Australia for final stage testing before release. Another important role of the project is to maintain sufficient quantities of pedigree seed to allow rapid commercialisation of new varieties.

Recent cultivars (Mandelup and Jenabillup) and advanced material in the existing program have shown possible further increases in yield potential. The following traits are important in narrow-leaf varieties for eastern Australia:

- yield
- early-mid flowering
- early vigour
- erect growth
- rapid pod fill and seed development
- high biomass and good height at flowering in drier environments
- restricted biomass and reduced height combined with good lodging resistance in favourable environments and seasons
- good mainstream pod set combined with flexible indeterminate growth to allow filling of pods along secondary and tertiary branches given the right seasonal conditions.

Primary breeding objectives

Primary breeding objectives required by growers, end-users and the industry for south east Australia include:

- increased grain yield, yield reliability, and good agronomic type with market acceptance
- resistance to phomopsis, anthracnose and grey spot
- resistance to Cucumber Mosaic Virus (CMV) seed transmission, Bean Yellow Mosaic Virus (BYMV), and brown leaf spot
- height of lowest pod—a practical consideration for harvest, especially in low-rainfall areas
- lodging resistance (high-rainfall environments)
- reduced pod shattering
- good tolerance to triazines (simazine pre-emergent/ metribuzin post-emergent)
- total alkaloid levels must be below 0.02%
- total crude protein content maintained at >30% with real potential to increase
- early vigour to help improve weed competition.

Figure 1: Narrow-leaf lupin experiment at Brocklesby in 2013. Photo: M Richards

Results 2013

In 2013, 213 Stage 2 lines imported from WA were grown successfully under flood irrigation at the Yanco Agricultural Institute. The lines were sown on 10 May 2013 and scored for winter vigour, days to flowering, flowering period, harvest score and phenotype notes. An average total of 30 kg of seed was harvested from all lines.

In 2013, 48 lines promoted from the 2012 Stage 2 imported lines were tested in replicated Stage 3 trials in NSW at Brocklesby, Cowra, Cootamundra and Wagga Wagga. The results of these trials (*Table 1*) have enabled 19 lines to be promoted to Stage 4 testing in 2014.

Another important role of the project is the advancement of pedigree seed to minimise the time to release of new varieties. In 2013, over 10 tonnes of pedigree seed of advanced germplasm was produced at Wagga Wagga.

Also in 2013, 18 advanced Stage 4 lines were provided for National Variety Testing trials (NVT) in NSW, SA and Vic. Equivalent Stage 4 trials were also conducted at Brocklesby, Cowra, Cootamundra and Wagga Wagga.

Summary 2013

The 2013 season started with a late break on 13 May at Wagga Wagga, so the breeding trials were sown in the last half of May. We received near average to below average winter rainfall followed by a drier than average spring. Wagga Wagga received 251 mm of growing season rainfall compared with the long-term average of 329 mm. These conditions favoured the shorter season and quicker-maturing varieties.

A national multi-environment trials analysis was completed for 2013 and as a result the following advanced lines WALAN 2385, WALAN 2448, and WALAN 2474 have been retained for further NVT testing in 2014.

Table 1: Stage 4 narrow-leaf lupin breeders trials 2013. Adjusted yield (t/ha) and yield expressed as percentage of site mean.

Nearest town	Cootamundra		Cowra		Brocklesby		Wagga Wagga	
Trial ID	LMNB13COOT2		LMNB13COWR2		LMNB13BROC2		LMNB13WARI2	
Variety name	t/ha	% smy	t/ha	% smy	t/ha	% smy	t/ha	% smy
Wonga	2.22	102	2.69	95	1.73	90	1.96	90
Jenabillup	2.05	94	2.90	102	1.77	92	2.02	93
Jindalee	1.65	76	2.32	82	1.94	101	1.78	82
Mandelup	2.21	101	2.76	97	2.21	116	2.45	113
PBA Barlock	2.31	106	3.04	107	2.15	113	2.12	98
PBA Gunyidi	2.46	113	2.90	102	1.97	103	2.33	107
Quilinock	2.09	96	2.74	97	1.45	76	1.84	85
04L085-ARR1-[F5]-17	2.06	94	2.79	99	1.76	92	2.27	105
04L087-ARR1-[F5]-16	2.21	101	3.11	110	2.01	105	2.38	110
WALAN2385	2.43	112	2.87	101	1.83	96	2.31	106
WALAN2448	2.45	112	3.09	109	2.32	122	2.26	104
WALAN2452	2.01	92	2.50	88	1.98	104	2.19	101
WALAN2469	2.07	95	2.82	100	2.01	105	2.39	110
WALAN2471	2.30	105	2.94	104	2.06	108	2.14	99
WALAN2472	2.06	94	2.96	105	1.85	97	2.09	96
WALAN2474	2.21	101	2.91	103	1.83	95	2.18	100
WALAN2477	2.29	105	2.77	98	1.50	79	2.10	97
WALAN2479	2.19	100	2.90	102	2.04	107	2.27	104
WALAN2471	2.30	105	2.94	104	2.06	108	2.14	99
Site mean (t/ha)	2.18		2.83		1.91		2.17	
CV (%)	6.56		5.54		5.84		3.26	
Probability	<0.001		<0.001		<0.001		<0.001	
LSD (t/ha)	0.24	11	0.25	9	0.18	10	0.12	5
Sowing date	21 May 2013		18 May 2013		20 May 2013		19 May 2013	
Harvest date	12 Dec. 2013		09 Dec. 2013		16 Dec. 2013		23 Nov. 2013	

Results 2014

In 2014, 224 Stage 2 lines imported from WA were grown successfully under flood irrigation at the Yanco Agricultural Institute. The lines were sown on 15th May 2014 and scored for winter vigour, days to flowering, flowering period, harvest score and phenotype notes. An average total of 25 kg of seed was harvested from all lines.

In 2014, 44 lines promoted from the 2013 Stage 2 imported lines were tested in replicated Stage 3 trials in NSW at Brocklesby, Cowra, Cootamundra and Wagga Wagga. The results of these trials have enabled 47 lines to be promoted to Stage 4 testing in 2015.

Another important role of the project is the advancement of pedigree seed to minimise the time to release of new varieties. In 2014, over 10 tonnes of pedigree seed of advanced germplasm was produced at Wagga Wagga.

Also in 2014, 18 advanced Stage 4 lines were provided for National Variety Testing trials (NVT) in NSW, SA and Vic. Equivalent Stage 4 trials were also conducted at Brocklesby, Cowra, Cootamundra and Wagga Wagga.

Summary 2014

The 2014 season started with an unusually early break, so the breeding trials were sown in the sowing window from late April to mid-May. Generally in the southern region we received above average March to June rainfall followed by below average July to November rainfall with a quick dry seasonal finish.

The wet autumn provided an ideal green bridge for aphid survival, which led to extensive cucumber mosaic and bean yellow mosaic virus across lupin growing areas. This enabled some good virus resistance scores to be made across experiment sites.

A series of significant frosts in late July and early August highlighted the increased risk of damage which can occur when current early flowering varieties are sown too early. Despite suffering a dry spring, Wagga Wagga received 278 mm of growing season rainfall compared with the long-term average of 329 mm. These conditions favoured the shorter season and quicker-maturing varieties.

A national multi-environment trials analysis was completed for 2014 and as a result the following

Table 2: Adjusted yield (t/ha) and yield expressed as percentage of site mean for 2014 Stage 4 narrow-leaf lupin breeders trials.

Nearest town	Cootamundra		Cowra		Brocklesby		Wagga Wagga	
Trial ID	**LMNB14COOT2**		**LMNB14COWR2**		**LMNB14BROC2**		**LMNB14WARI2**	
Variety name	**t/ha**	**% smy**	**t/ha**	**% smy**	**t/ha**	**% smy**	**t/ha**	**% smy**
Jenabillup	3.19	107	1.37	101	3.28	96	1.91	100
Jindalee	2.33	78	0.98	73	2.94	86	1.61	84
Mandelup	2.75	92	1.04	77	3.42	100	1.84	96
PBA Barlock	2.77	93	1.43	106	3.63	106	2.04	107
PBA Gunyidi	3.79	127	1.68	125	3.33	97	2.06	108
Quilinock	2.94	98	1.36	101	3.05	89	1.65	86
WALAN2385	2.95	99	1.36	101	3.6	105	2.07	108
WALAN2448	2.86	96	1.12	83	3.62	106	1.98	103
WALAN2474	3.25	109	1.34	100	3.45	101	1.87	98
WALAN2488	2.35	79	1.46	108	3.82	112	2.04	107
WALAN2489	3.2	107	1.38	103	3.3	96	2.21	115
WALAN2491	3.1	104	1.62	120	3.5	102	2.13	111
WALAN2493	2.73	92	1.54	114	3.6	105	1.86	97
WALAN2497	3.71	124	1.23	91	3.49	102	1.94	102
WALAN2498	3.09	103	1.58	117	3.54	103	1.98	103
WALAN2499	2.76	92	1.37	102	2.59	76	1.82	95
WALAN2519	3.02	101	1.34	100	3.46	101	2.09	109
Wonga	2.3	77	1.21	90	3.33	97	1.83	96
Site mean (t/ha)	2.99		1.35		3.43		1.91	
CV (%)	6.06		10.72		3.24		5.23	
Probability	<0.001		<0.001		<0.001		<0.001	
LSD (t/ha)	0.3	10	0.25	19	0.19	5	0.17	9
Sowing date	1 May		13 May		9 May		28 Apr	
Harvest date	10 Dec		17 Dec		8 Dec		25 Nov	

Figure 2: Narrow-leaf lupin experiment at Brocklesby in 2014.
Photo: M Richards

advanced lines WALAN 2385, WALAN 2448, and WALAN 2498 have been retained for further NVT testing in 2015.

Acknowledgements

This project (DAW00237, 2014–2016) is jointly funded by GRDC and NSW DPI.

Thank you to the NSW DPI farm staff at Wagga Wagga, Yanco and Cowra for their assistance in managing the experiment sites. Also, thank you to our long-term farmer collaborators Andrew Bell and family 'Bindinyah' Cootamundra and Gary and Heather Drew 'Northwood' Brocklesby.

Evaluating remaining Albus lupin breeding germplasm held at Wagga Wagga 2013 and 2014

Mark Richards, Dr Eric Armstrong, Oliver Owen and Scott Clark NSW DPI, Wagga Wagga

Key findings

- WK338 is currently being bulked up for commercial release in 2016.
- Data from long-term, multi-environment trials show that WK338 has a yield advantage over Luxor and Rosetta.
- WK338 also has moderate pleiochaeta root rot and pod phomopsis resistance, similar to Luxor and Rosetta.
- The project plans to proceed with the release of WK338 subject to final alkaloid testing which is currently underway.
- The Stage 3 trials in 2013 and 2014 identified five lines yielding equal or better than Luxor.

Introduction

The aim of this project is to evaluate elite *Lupinus albus* breeding lines remaining from the *Lupinus albus* Breeding Program that was closed in 2009. We are aiming to identify and release varieties from these lines with improved yield, disease resistance and agronomic type that prove to be well adapted to southern Australia. This project runs from 1 January 2012 to 30 June 2015.

The *Lupinus albus* Breeding Program commenced at Wagga Wagga in 1992 and ran for 17 years before closing in 2009. Luxor and Rosetta, two vastly improved varieties, were released during this period.

Currently, over 95% of the Australian Albus lupin industry is located in NSW, with approximately 60% of this grown in the southern region. As one of the better adapted pulses to southern NSW, Albus lupins have the potential for both high yield and expansion subject to market demand. Albus lupins provide another pulse crop option to a sustainable farming system, bringing break-crop benefits to cropping rotations through crop diversification and biologically fixed nitrogen.

Specific variety traits targeted for Albus lupin across southern Australia include:

- higher yields (exceeding current varieties–Luxor and Rosetta)
- Pleiochaeta root-rot resistance (PRR-R) and anthracnose resistance (ant-R)
- Phomopsis resistance
- good plant architecture combined with shattering and lodging resistance
- market acceptance – high protein, white seed
- lodging resistance (high rainfall environments)
- maintain low-alkaloid, 100% bitter-free
- maintain low levels of seed manganese.

During 2013 a large pipeline of evaluation was successfully conducted across central and southern NSW and the project is well on track. While 2013 was particularly dry, all sites were sown on time and a good set of analysed data was obtained to allow informed selection decisions. This work included National Variety Trials (NVT), Stage 4, Stage 3 trial evaluation and selections at Wagga Wagga, Brocklesby, Cowra and Cootamundra, as well as bulking and single plant selections from F6, F5, F4 and F3 bulk populations at Wagga Wagga.

This project runs parallel with and complements Lupinus angustifolius evaluation at Wagga Wagga.

Results 2013

1. NVT/Stage 4

The project provided seed of 12 advanced Albus lines for NVT/Stage 4 evaluation at seven NVT sites and four project sites in southern NSW in 2013. Data was collected and submitted to the NVT data base to allow a larger multi-environment trials (MET) analysis to be completed.

2. Stage 3 Evaluation

Yield and agronomic characters were assessed on 26 breeding lines at Wagga Wagga, Brocklesby, Cowra and Cootamundra with five lines yielding equal to or better

Figure 1: Albus experiment at Brocklesby in 2013. Photo: M Richards

Table 1: Stage 4 Albus lupin breeders trials 2013. Adjusted yield (t/ha) and yield expressed as percentage of site mean.

Nearest town	Cootamundra		Cowra		Brocklesby		Wagga Wagga	
Trial ID	LMAB13COOT2		LMAB13COWR2		LMAB13BROC2		LMAB13WARI2	
Variety name	t/ha	% smy	t/ha	% smy	t/ha	% smy	t/ha	% smy
Luxor	2.62	108	2.89	98	2.21	102	1.96	107
Rosetta	2.40	99	2.90	99	2.32	106	1.81	99
Kiev Mutant	2.21	91	3.17	108	2.14	98	1.82	99
Ultra	2.34	96	2.84	97	2.14	98	1.88	102
A03X21-3	2.47	102	2.90	98	2.11	97	1.76	96
A03X237-10	2.28	94	3.10	105	2.26	104	1.82	100
A03X269-2	2.51	103	2.95	100	2.19	100	1.79	98
A04X100-1	2.37	97	2.61	89	2.09	96	1.79	98
A04X81-14	2.44	100	2.86	97	2.01	92	1.77	97
A04X81-17	2.33	96	3.10	105	2.11	97	1.81	99
LAB50300115	2.46	101	3.05	104	2.24	103	1.87	102
LAB50300354	2.11	87	2.94	100	2.09	96	1.81	99
LAB50300500	2.62	108	2.91	99	2.26	104	1.80	98
LAB50300978	2.52	104	3.02	103	2.15	99	1.89	103
LAB50301087	2.42	100	2.86	97	2.16	99	1.81	99
LAB50301329	2.53	104	3.06	104	2.24	103	1.82	99
WK236	2.59	107	2.91	99	2.21	101	1.84	100
WK338	2.50	103	2.92	99	2.30	106	1.92	105
Site mean (t/ha)	2.43		2.94		2.18		1.83	
CV (%)	8.55		3.83		4.06		3.68	
Probability	0.16		<0.001		<0.001		0.03	
LSD (t/ha)	0.35	15	0.19	6	0.15	7	0.12	6
Sowing date	21 May 2013		18 May 2013		20 May 2013		19 May 2013	
Harvest date	12 Dec. 2013		9 Dec. 2013		16 Dec. 2013		23 Nov. 2013	

than Luxor. Selected lines will be field tested further in 2014.

Further inter-state evaluations were organised at Walkaway (near Geraldton), WA and Tarlee South Australia. Unfortunately, poor site selection at both these sites led to highly variable inconclusive data. Amongst these evaluations were seven lines showing good anthracnose resistance compared with Andromeda. It will be necessary to repeat these interstate evaluations in 2014.

Bitter-free pedigree seed of 35 Stage 3 and 4 lines was also successfully advanced in a screen house at Wagga Wagga in 2013.

3. Evaluation of diverse germplasm

Before closing, the *Lupinus albus* Breeding Program had developed over 1000 breeding lines combining good quality with varying levels of resistance to Pleiochaeta root rot (from Crete and Azores wildtypes) and to anthracnose (from Ethiopian wildtypes). Selected lines from this diverse germplasm are being evaluated at Wagga Wagga.

Summary 2013

WK338 is currently being bulked up for release in 2016, with long-term MET data showing it has 1%–2% yield advantage over Luxor and Rosetta. It also has moderate pleiochaeta root rot and pod phomopsis resistance, similar to Luxor and Rosetta. The project plans to proceed with the release of WK338 subject to alkaloid testing which is currently underway.

The Stage 3 trials in 2013 identified five lines yielding equal to or better than Luxor. Selected lines will be further evaluated in field trials in 2014.

Table 2: Soil test results for 2013 experiment sites.

Sample ID	Unit	Cootamundra	Cowra	Brocklesby	Wagga Wagga
EC	dS/m	0.4	0.06	0.19	0.14
pH_{Ca}	pH units	6.4	6.2	5.5	5.4
pH_{Wr}	pH units	6.8	6.9	6.1	6.0
Sulfur (KCl_40)	mg/kg	20	5.0	21	11
Bray #1 Phosphorus	mg/kg	27	31	48	74
Phosphorus Buffer Index + Col P	L/kg	95	17	47	50
Organic Carbon	%	4.4	1.0	2.2	1.9
Total Nitrogen	%	0.44	0.08	0.2	0.19
Exchangeable Cations:					
Aluminium	cmol(+)/kg	<0.1	<0.1	<0.1	<0.1
Calcium	cmol(+)/kg	18	4	7	6.0
Potassium	cmol(+)/kg	1.1	0.8	1.8	1.3
Magnesium	cmol(+)/kg	1.5	0.43	0.93	1.2
Sodium	cmol(+)/kg	0.051	<0.03	0.03	<0.03
CEC	cmol(+)/kg	21	5.2	9.8	8.6
Calcium/Magnesium Ratio		12	9.4	7.6	5.2
Aluminium Saturation	%	<0.5	<2	<1	<2
Exchangeable Calcium	%	87	77	71	71
Exchangeable Potassium	%	5.3	15	19	15
Exchangeable Magnesium	%	7.1	8.1	9.4	14
Exchangeable Sodium	%	0.24	<0.6	0.31	<0.4

Results 2014

1. NVT/Stage 4

The project provided seed of 12 advanced Albus lines for NVT/Stage 4 evaluation at seven NVT sites and four project sites in southern NSW in 2014. Data was collected and submitted to the NVT data base to allow a larger multi-environment trials (MET) analysis to be completed.

2. Stage 3 Evaluation

Yield and agronomic characters were assessed on 24 breeding lines at Wagga Wagga, Brocklesby, Cowra and Cootamundra. As a result 13 selected lines will continue to be tested in NVT trials in 2015.

Further inter-state evaluations were organised at Walkaway and Mingenew in WA. Amongst these evaluations were seven lines showing good anthracnose resistance compared with Andromeda.

Bitter-free pedigree seed of 24 Stage 3 and 4 lines was also successfully advanced in a screen house at Wagga Wagga in 2014, along with a large pedigree block of WK338.

3. Evaluation of diverse germplasm

Before closing, the *Lupinus albus* Breeding Program had developed over 1000 breeding lines combining good quality with varying levels of resistance to Pleiochaeta root rot (from Crete and Azores wildtypes) and to anthracnose (from Ethiopian wildtypes).

Selected lines from this diverse germplasm were also evaluated at Wagga Wagga in 2014.

Summary 2014

WK338 is currently being bulked up for release in 2016, with long-term MET data showing it has 1%–2% yield advantage over Luxor and Rosetta. It also has moderate pleiochaeta root rot and pod phomopsis resistance, similar to Luxor and Rosetta. The project plans to proceed with the release of WK338 subject to alkaloid testing which is currently underway.

The Stage 3 trials in 2014 identified some lines with yields equal to Luxor. 7 of these lines have been selected for further evaluation in NVT field trials in 2015.

Figure 2: Albus experiment at Cootamundra in 2014
Photo: M Richards.

Table 3: Adjusted yield (t/ha) and yield expressed as percentage of site mean for 2014 Stage 4 Albus lupin breeders trials.

Nearest town	Cootamundra		Cowra		Brocklesby		Wagga Wagga	
Trial ID	**LMAA14COOT2**		**LMAA14COWR2**		**LMAA14BROC2**		**LMAA14WARI2**	
Variety name	**t/ha**	**% smy**	**t/ha**	**% smy**	**t/ha**	**% smy**	**t/ha**	**% smy**
Kiev Mutant	4.00	103	3.12	102	3.31	99	2.11	90
Luxor	3.93	101	3.14	102	3.36	101	2.41	103
Rosetta	3.83	98	3.06	100	3.26	98	2.45	105
Ultra	4.12	106	3.05	100	3.39	102	2.33	100
WK236	3.89	100	3.06	100	3.38	101	2.26	96
WK338	3.80	98	3.18	104	3.34	100	2.35	101
WK421	3.95	102	3.17	103	3.32	99	2.32	99
WK422	3.90	100	3.18	104	3.27	98	2.38	102
WK423	4.01	103	3.16	103	3.49	105	2.30	98
WK424	3.75	96	3.04	99	3.41	102	2.42	103
WK425	3.87	99	3.14	103	3.39	101	2.47	105
WK426	3.97	102	3.11	102	3.36	101	2.33	100
Site mean (t/ha)	3.89		3.07		3.34		2.34	
CV (%)	3.36		4.43		2.53		3.42	
Probability	<0.001		0.0194		0.0191		<0.001	
LSD (t/ha)	0.22	6	0.23	7	0.14	4	0.14	6
Sowing date	1 May		13 May		9 May		28 Apr	
Harvest date	10 Dec		17 Dec		8 Dec		25 Nov	

Table 4: Soil test results for 2014 Stage 4 Albus lupin breeders trial sites.

	Unit	Cootamundra	Cowra	Brocklesby	Wagga Wagga
EC	dS/m	0.058	0.042	0.068	0.051
pH_{Ca}	pH units	5	4.9	5.6	5.5
pH_{Wr}	pH units	6	5.9	6.6	6.5
Sulfur (KCl_40)	mg/kg	8.2	4.5	5.3	3.4
Bray #1 Phosphorus	mg/kg	18	22	25	34
Phosphorus Buffer Index + Col P	L/kg	79	30	46	51
Organic Carbon	%	2.2	0.8	1.7	1.3
Total Nitrogen	%	0.19	0.094	0.16	0.14
Exchangeable Cations:					
Aluminium	cmol(+)/kg	<0.1	<0.1	<0.1	<0.1
Calcium	cmol(+)/kg	11	2.6	7.1	6.3
Potassium	cmol(+)/kg	1.2	0.61	1.5	1.2
Magnesium	cmol(+)/kg	1.9	0.45	0.86	0.74
Sodium	cmol(+)/kg	<0.03	<0.03	<0.03	<0.03
CEC	cmol(+)/kg	14	3.8	9.5	8.3
Calcium/Magnesium Ratio		5.6	5.8	8.2	8.5
Aluminium Saturation	%	<0.71	<2.6	<1	<1.2
Exchangeable Calcium	%	77	69	75	76
Exchangeable Potassium	%	8.9	16	15	14
Exchangeable Magnesium	%	14	12	9.1	9
Exchangeable Sodium	%	<0.21	<0.79	<0.32	<0.36

Acknowledgements

This project (DAW00157, 2012–2015) is jointly funded by GRDC and NSW DPI.

Thank you to the NSW DPI farm staff at Wagga Wagga, Yanco and Cowra for their assistance in managing the sites. Also thank you to our farmer collaborators Andrew Bell and family 'Bindinyah' Cootamundra, and Gary and Heather Drew 'Northwood' Brocklesby.

Faba beans on acidic soils in southern NSW: time of sowing effects on yield

Dr Eric Armstrong, Luke Gaynor, Gerard O'Connor, Dr Sarah Ellis and Dr Neil Coombes NSW DPI, Wagga Wagga

Key findings

- Sow faba bean from 20 April (low rainfall zone) to 15 May (higher rainfall zone) on acidic soils in southern NSW.
- Sowing earlier than 20 April can result in excessive lodging and disease risk.
- Sowing later than mid-May lowers yield and produces shorter plants, affecting harvesting.
- Time of sowing has a greater impact on grain yield than choice of variety.

Introduction

Variety evaluation and agronomic investigation of faba bean has been undertaken at Wagga Wagga Agricultural Institute as part of a national research program. Faba bean shows considerable promise as a profitable crop in its own right and as a pulse break crop in southern NSW cropping sequences. It is a competitive, erect, vigorous crop with high dry matter production and grain yield potential. Faba bean appears slightly more frost hardy and more tolerant of heavy soils than other pulses, fixes large amounts of nitrogen, has non-shattering pods and is well suited to mechanical harvest. It is important to adhere to tight disease protocols across the entire season. Avoid sowing the crop too early which can promote disease, excess growth and lodging, particularly in favourable extended springs. Equally, seeding too late may deprive the crop of height, bulk and yield, especially in drier seasons with quick early springs.

Site details

The site was limed in 2011 lifting the pH_{Ca} to 5.2 at 0–10 cm depth (*Table 1*), providing a more favourable environment for pulses and their associated rhizobia. The paddock had a failed pasture in 2013 which was chemically fallowed in the spring.

Treatments

Eight varieties/breeding lines were included in this experiment but for simplicity and clarity, only four commercial varieties and one breeding line are reported here. Three sowing times were undertaken; 2 April, 24 April and 12 May. Stubble was absent and plots direct-drilled using a six-row coneseeder with 300 mm row spacing and GPS guidance. At seeding, 80 kg/ha SuPerfect® grain legume fertiliser (NPKS 0:13.8:0:6.1) was placed approximately 2 cm below the seed. Group F peat inoculant was mixed with water in an on-board tank and injected down each sowing tine at sowing. Normal recommended cultural practices were adopted for weed, insect and disease control throughout the season.

Table 1: Soil analysis of paddock 20A Wagga Wagga Agricultural Institute 2014.

Depth	0-10 cm	10-20 cm
pH_{Ca}	5.2	5.0
Al Sat %	1.7	2.5
Nitrate N	8.5	15.0
Ammonium N	0.8	1.1
P (Colwell)	34.0	13.0
CEC	7.0	6.5

Results

Season effects

Chocolate spot (*Botrytis* sp.) fungal disease was present in the crops, especially the early times of sowing, but did not become severe. Fungal disease requires moist conditions, with 90% relative humidity optimal for disease spread, and was held in check by the dry weather in the spring. The high incidence of frosts through July and August caused stem splitting and bending that was most severe in the early sown crops. Overall, 2014 was a favourable pulse year at Wagga Wagga with minimal disease, above average yields and an early, dry harvest producing good quality unblemished seed.

Grain yield, dry matter production and harvest index (HI%)

Grain yields were between 2.8 and 3.1 t/ha, well above the expected long-term average of 1.8–2.0 t/ha for faba beans at Wagga Wagga. This result was remarkable given the very dry, warm July, August, September and October and the 2–3 weeks premature finish to the growing season.

Despite these good yields, differences between varieties and sowing times were not statistically significant This suggest that the dry spring created a levelling effect across all treatments, with moisture and temperature imposing a ceiling to potential yield. All treatments effectively ran out of moisture. These results support a sowing time window from early April to mid-May for faba bean. In this region, growers still need to be mindful of the pitfalls of sowing too early (prior to 15 April resulting in excessive height, lodging and disease) and sowing too late (short plants, loss of DM and grain yield).

Dry matter (DM) production was similar at the first two sowings (9.1–9.3 t/ha) but fell significantly (20%) when sowing was delayed to 12 May (average 7.5 t/ha). PBA Rana and PBA Samira produced significantly more DM at the first two sowings. The more vigorous growth of these two varieties was also reflected in higher NDVI readings at the early vegetative stage of both varieties, especially PBA Rana (data not shown).

Harvest index (HI%) was similar at the first two sowings (31–32%) but rose significantly at the final sowing (38%). Dry matter is converted more efficiently into grain yield with later sowings, but the down side to later sowing is less residual fixed N since a greater proportion of N is exported in the grain.

Plant height and podding

Varieties such as PBA Rana that flower and pod later tend to set pods on later nodes, higher up the stem than early varieties such as IX220D/2-5.

Plant height and height of bottom pods declined significantly with delayed sowing from 2 April to 12 May (*Figure 1*). Past experience shows this trend continues with further sowing delays. This has a significant effect on the harvester's ability to get below bottom pods and for this reason growers should not delay sowing.

In contrast, plants can grow too tall and lodge when sown too early, as occurred in this experiment at the first sowing (2 April; *Figure 2*). PBA Rana and Farah were most vulnerable to lodging under ideal early growing conditions.

All varieties were shorter at the second and third sowings and remained erect, simplifying management and harvest.

Growth and development phases

Delays in sowing constricts the flowering and grain fill phases of all faba bean varieties (*Figure 3*). For example, a 40 day difference at sowing (from 2 April to 12 May) was reduced on average to only a 12 day difference between varieties at the end flowering (range 17 September to 29 September), and further to only 4 days difference at maturity (range 27 October to 31 October).

This significant reduction of the growing period with later sowings was reflected in much shorter plants, more erect growth, less disease, reduced DM, a halving of the length of the flowering period (from 73 days to 37 days) and a significant reduction in the number of flowering nodes. Interestingly, yield remained unaffected, thus the late sown crop had a significantly higher harvest index than the early sown crops. This reflects the significant frost damage to the April sown crops which were unable to fulfil their yield potential.

Nura was the latest variety to flower at all sowing dates, preceded by PBA Rana and PBA Samira.

IX220D/2-5 is a very early northern NSW breeding line and was included in this experiment to compare phenology to southern lines. It started flowering 60, 37 and 18 days earlier than PBA Rana at the 1st, 2nd and 3rd sowing time respectively, but finished flowering

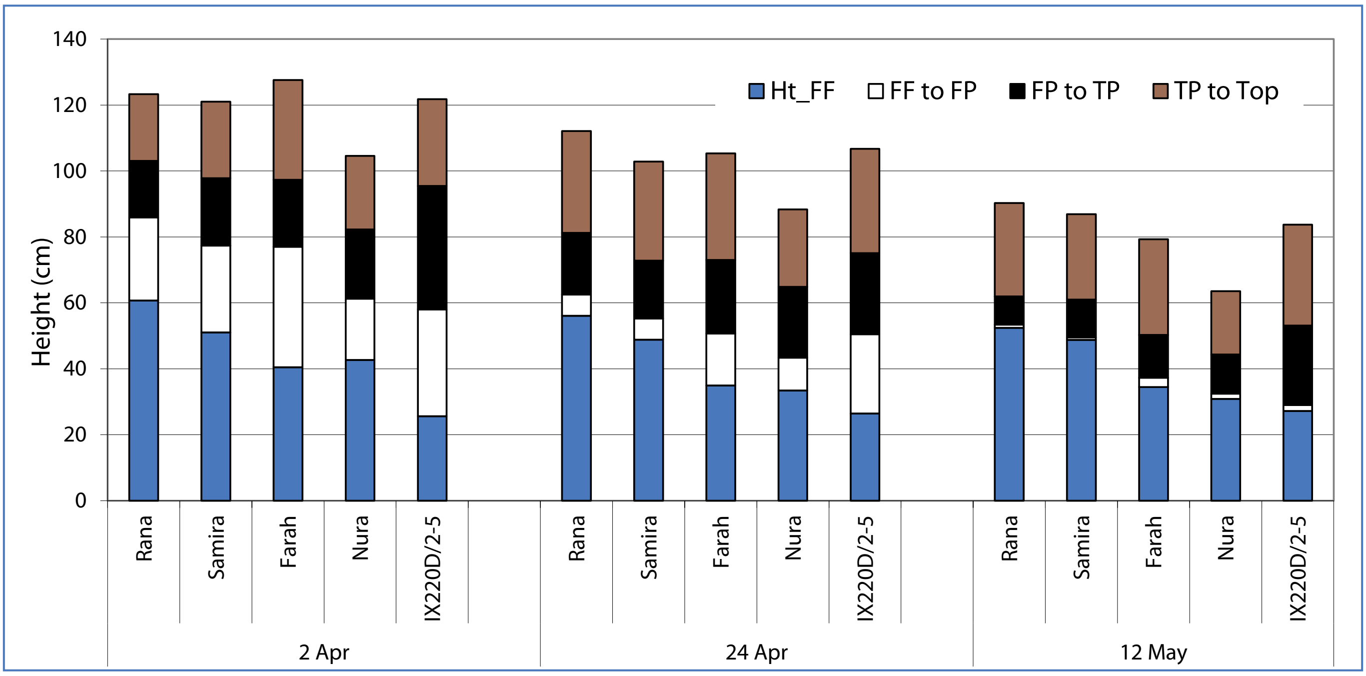

Figure 1: Effect of sowing date and variety of faba bean on height of the stem to first flower (FF), first pod (FP), top pod (TP) and to the top of the plant (Top).

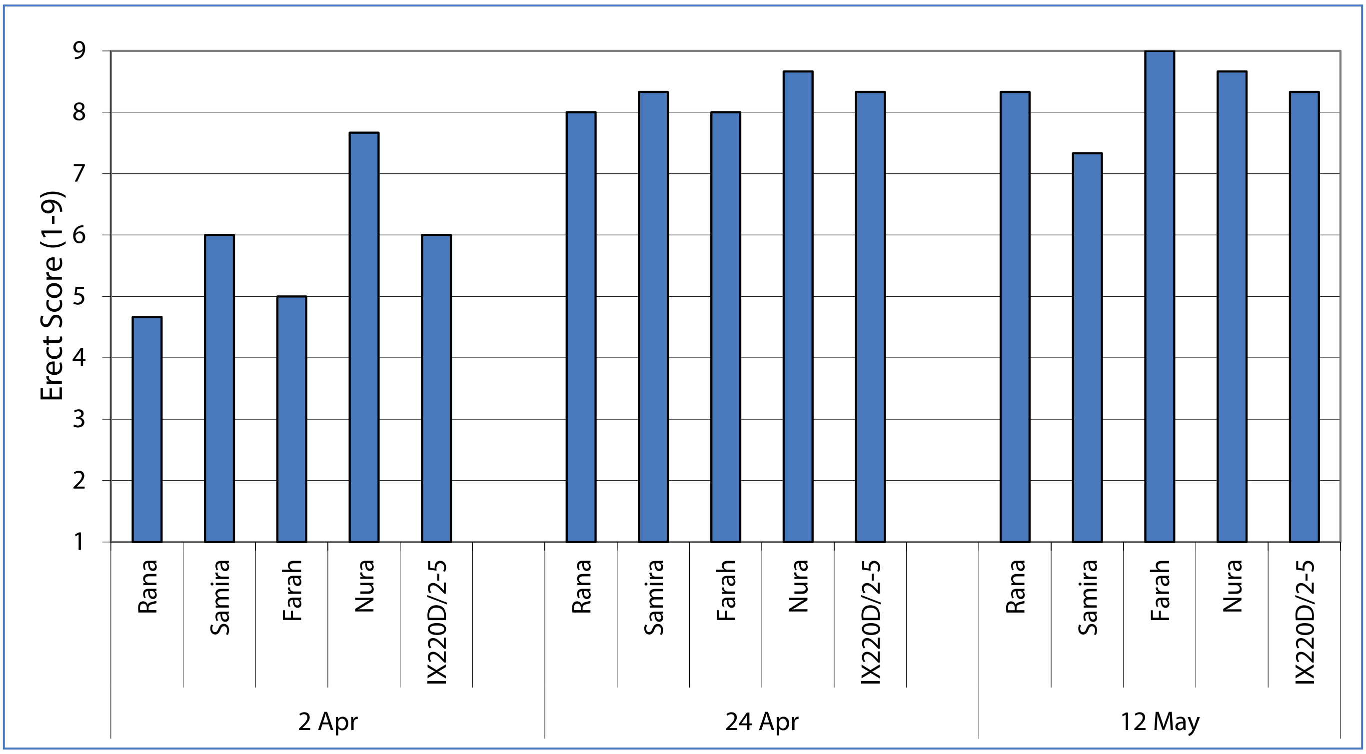

Figure 2: Effect of sowing date and variety on faba bean lodging. The scale for erectness uses a 1–9 score, where 9 is completely vertical and 1 completely flat.

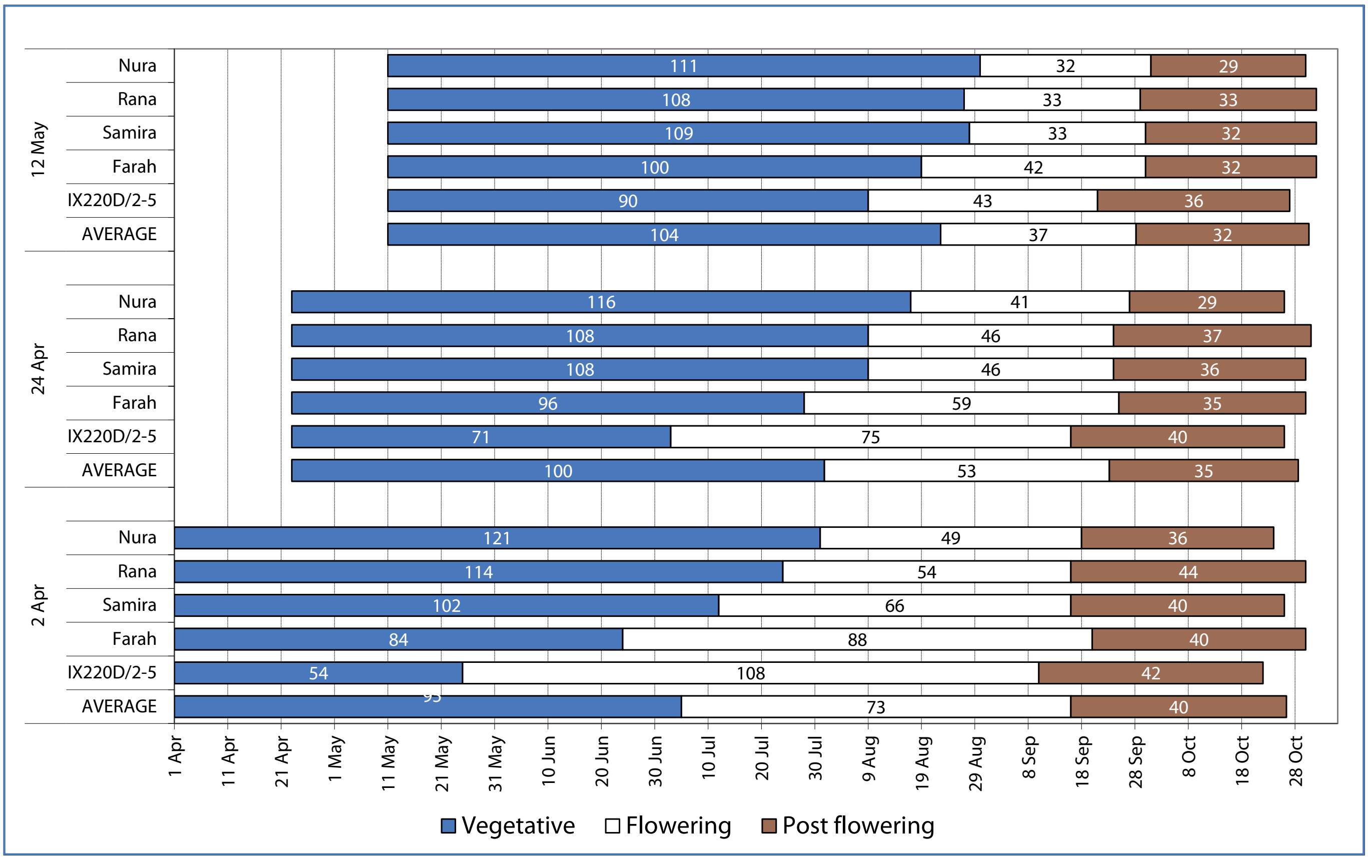

Figure 3: Development phases of five faba bean varieties at three sowing dates at Wagga Wagga in 2014.

only 6-8 days earlier. This wide flowering window results in a significantly larger number of podding nodes to potentially contribute to yield, and some insurance against environmental extremes during this period. It demonstrated a very high yield potential in 2013, but this advantage did not carry through to 2014.

Summary

Faba beans had above average yield (2.8–3.1 t/ha) in a dry spring at Wagga Wagga.

Early April sown treatments escaped a yield penalty from potential disease due to the dry spring, despite their high biomass. If an average spring occurs, the disease in the early sown treatments would be difficult to control with fungicides.

The early April sown crops suffered extensive damage from frosts which had a significant impact on grain yield potential.

The dry spring largely negated differences between varieties and time of sowing as yield potential was not reached.

Acknowledgements

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Technical assistance of Mr Jon Evans.

Effect of nitrogen rate and placement on yield of canola—Merriwagga 2013

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Dr Peter Martin and Karl Moore NSW DPI, Wagga Wagga

Key findings

- Hyola® 50 was significantly higher yielding than all other varieties in this experiment.
- The application of nitrogen resulted in a significant increase in grain yield.
- Rates of 30 kg/ha of N and above applied directly with the seed, reduced grain yield due to negative effects on crop establishment.

Introduction

Past research has highlighted nitrogen as a key driver of grain yield of canola. With the recent development of hybrid canola there is little data on how these canola varieties respond to nitrogen application compared with open-pollinated varieties.

This experiment was designed to test the regional suitability of current commercial canola cultivars as well as determine nitrogen application and rate recommendations for specific canola varieties.

Site details

Soil type	red sandy loam
Available N	97 kg/ha (0–90 cm)
Previous crop	wheat (2012 and 2011)
Sowing date	29 April 2013 with tyne machine
Soil moisture	approximately 40 cm of moist soil
In-crop rainfall	186.5 mm
Starter fertiliser	60 kg Superfect
Harvest date	7 November 2013

Treatments

6 canola varieties	ATR-Stingray, Hyola® 50, Hyola® 555TT, 43Y85 CL, 45Y86 CL, Victory V3002
5 nitrogen rates	0, 15, 30, 60 and 120 kg/ha
2 nitrogen placement strategies	Urea applied directly with seed or urea pre-drilled in a separate pass

Results

There was a significant effect of variety in this experiment ($P<0.001$) with Hyola® 50 yielding higher than all other varieties (*Figure 1*).

There was an interaction between N rate and application method ($P<0.001$). As N rate increased so too did grain yield for the pre-drilled N treatment. However, where urea was applied with seed there was a positive grain yield response to the 15 kg/ha N rate but

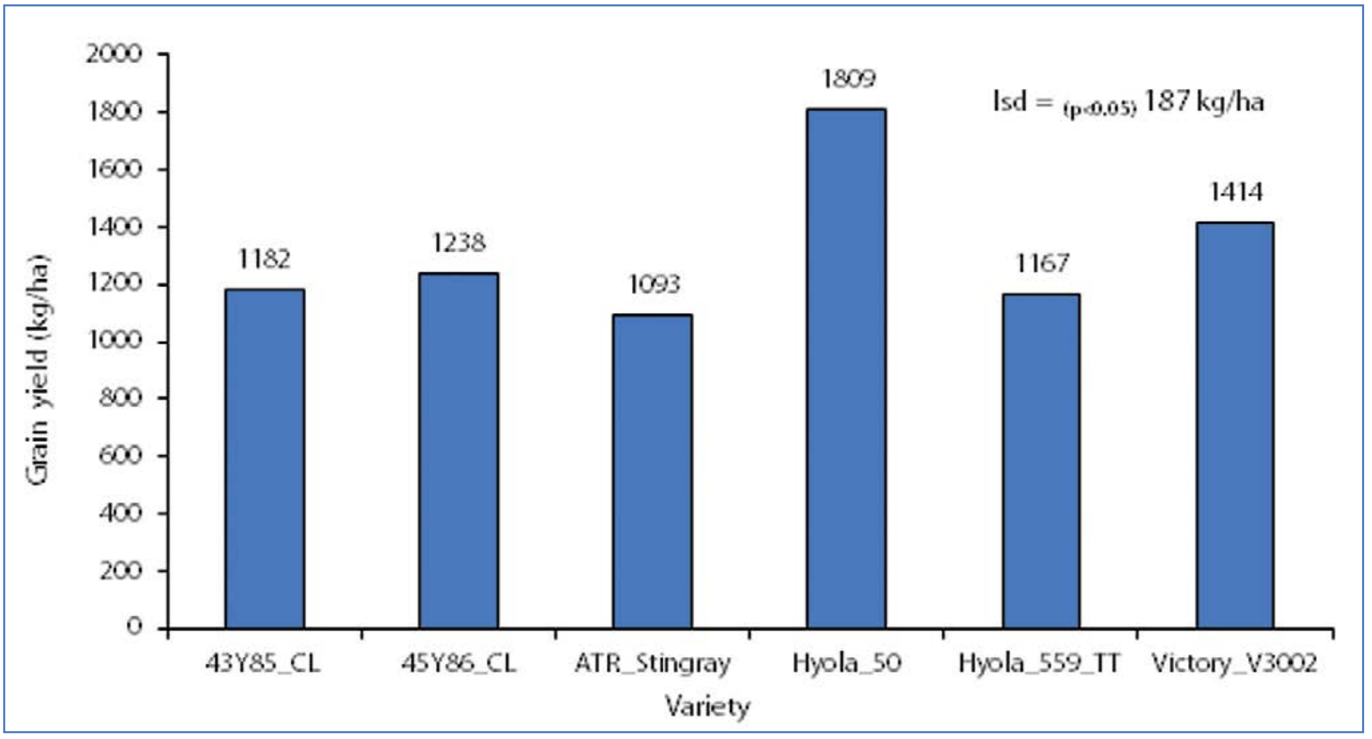

Figure 1: Grain yield of varieties averaged across all nitrogen and fertiliser placement treatments in an experiment at Merriwagga 2013.

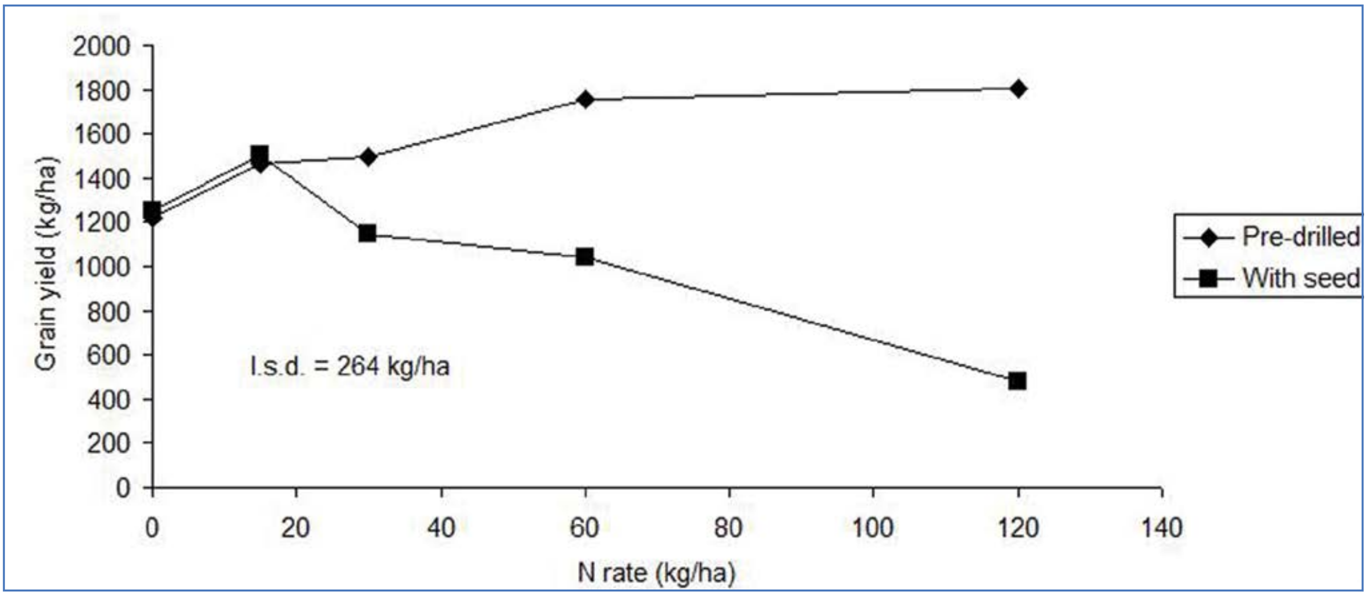

Figure 2: Grain yield of fertiliser placement and nitrogen rate interactions averaged across all varieties in an experiment at Merriwagga 2013.

grain yield then declined as N rate increased further (*Figure 2*). At 30 kg N/ha, grain yield reduced by 0.35 t/ha when N was placed with the seed compared with being pre-drilled. Similarly, at 60 kg N/ha and 120 kg N/ha, the yield reduction was 0.72 t/ha and 1.32 t/ha respectively.

Summary

In this experiment, selection of the correct variety was extremely important. Hyola® 50 exhibited superior early vigour which set it up to respond to growing season rainfall. Strong early vigour is extremely important for high yields in marginal western environments. Hyola® 50 has continually ranked at the top of the trials in this region over several seasons.

Nitrogen application is another important factor in this experiment. There was a strong response to nitrogen application, however, separating nitrogen from the seed at sowing was very important especially when applying rates above 15 kg/ha. This effect was similar in the same experiment when conducted in 2012. These trials have clearly shown that canola is very sensitive to nitrogen rates above 15 kg/ha with seed.

Acknowledgements

This experiment is part of the *Variety specific agronomy package* project (DAN00129, 2009–2012), jointly funded by GRDC and NSW DPI, and conducted by AgGrow Agronomy.

Effect of nitrogen rate on grain yield and grain oil concentration of canola—Canowindra 2014

Colin McMaster, Rob Dunkley NSW DPI, Cowra, Rohan Brill NSW DPI, Wagga Wagga and Don McCaffery NSW DPI, Orange

Key findings

- Highest yielding variety was 45Y88 CL, 0.44 t/ha higher than the lowest yielding variety, ATR-Gem.
- There was no significant interaction between variety and N response.
- Hybrids were more N-use efficient than open-pollinated varieties.
- Soil N levels are likely to be lower following a hybrid canola compared to open-pollinated varieties.
- Nitrogen applied at 40 kg N/ha produced maximum grain yield with a 0.24 t/ha benefit over the Nil N rate.
- Oil concentration was reduced as N rate exceeded 40 kg N/ha.
- Victory V3002 had significantly higher oil concentration than other varieties.
- Total harvested oil was 181 kg/ha more with hybrids than open-pollinated varieties.

Introduction

Advances in canola breeding (hybrid technology) have commonly led to grain yield increases of 0.30–0.60 t/ha across southern NSW. It is hypothesised that an increase in grain yield potential may also require additional N inputs to meet crop N demand.

The aim of this experiment was to evaluate the effect of nitrogen rate on grain yield and grain oil concentration of six canola varieties. The varieties used in this experiment were selected to cover a range of canola phenology and herbicide groups, and include open-pollinated and hybrid Clearfield, open-pollinated and hybrid triazine tolerant (TT), and conventional-herbicide specialty-oil hybrid.

Site details

Location	Canowindra
Soil type	Red brown earth
Previous crop/s	Barley
Stubble management	Stubble retained
Sowing date	1 April 2014
Harvest date	13 November 2014
Fertiliser	80 kg/ha MAP
Soil pH_{Ca}	6.4
Nitrogen	60 kg N/ha predrilled as anhydrous ammonium
Phosphorus	96 mg/kg (Colwell)
In-crop rainfall	192 mm

Treatments

Six canola varieties	43C80 CL, 45Y88 CL, ATR-Gem, Hyola® 559TT, Hyola® 577CL, Victory V3002
Five nitrogen rates	0, 20, 40, 80 and 160 kg N/ha (pre-drilled urea)

* Paddock had a basal application of 60 kg N/ha applied prior to sowing (as anhydrous ammonia).

Results

Grain yield

Grain yield was significantly affected by variety selection (P<0.001) and nitrogen rate (P=0.0053). The interaction between variety and N rate was not significant (P=0.984) in this experiment.

The highest yielding variety was 45Y88 CL with a 0.44 t/ha grain yield benefit over the lowest yielding variety ATR-Gem (*Figure 1*).

Grain yield increased by 0.24 t/ha with the addition of 40 kg N/ha (*Figure 2*). The higher N fertiliser rates of 80 and 160 kg N/ha did not further increase grain yield.

Grain oil concentration (%)

Grain oil concentration was significantly affected by variety selection (P<0.001) and nitrogen fertiliser rate (P<0.001) (*Figure 3* and *4*). The interaction between variety and N rate (P=0.114) was not significant in this experiment.

Victory V3002 produced the highest grain oil concentration of 44.8%, which is 3.8 percentage points higher than the lowest grain oil concentration variety 45Y88 CL (41.0%).

Additional N fertiliser at rates of 80 kgN/ha and 160 kg N/ha reduced oil percentage points by 2.18 and 3.17 respectively compared to the 0 kg N/ha treatment.

Harvest oil yield

The amount of oil removed per hectare was significantly affected by variety (P<0.001), however N rate (P=0.251) and the interaction between N rate and variety was not significant (P=0.987) (*Figure 5*).

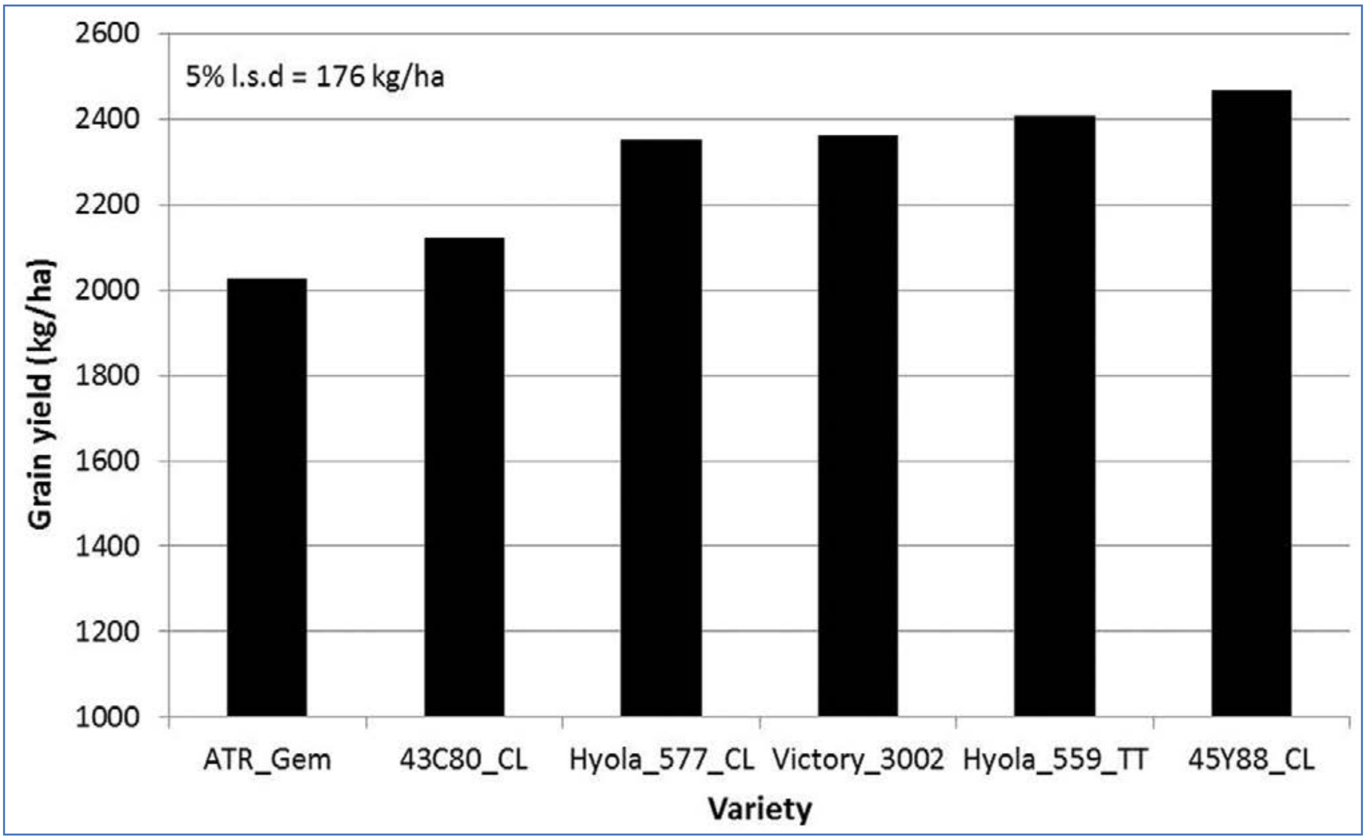

Figure 1: Grain yield of six canola varieties averaged across five nitrogen rates at Canowindra in 2014

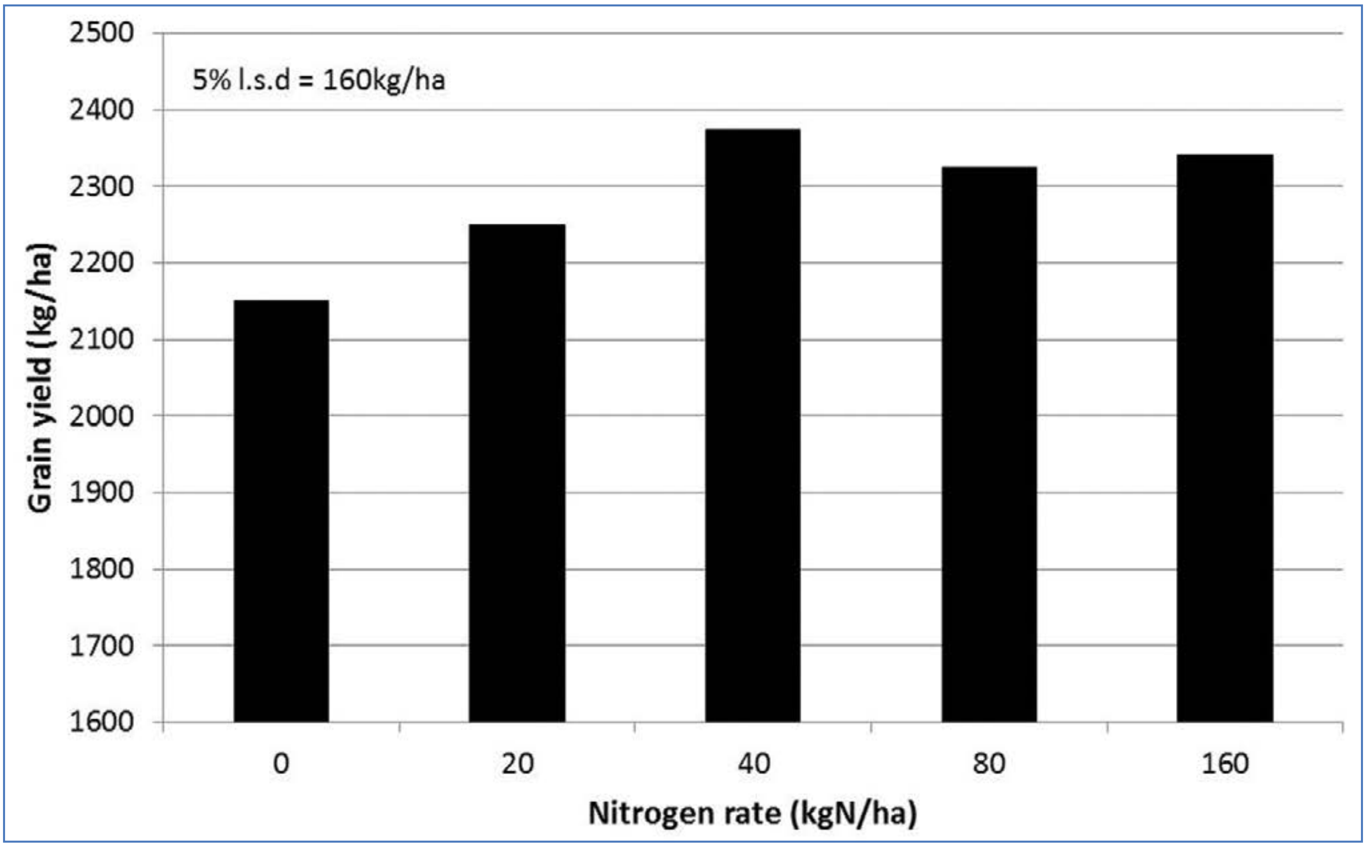

Figure 2: Grain yield benefit of five nitrogen fertiliser rates averaged across six canola varieties at Canowindra in 2014.

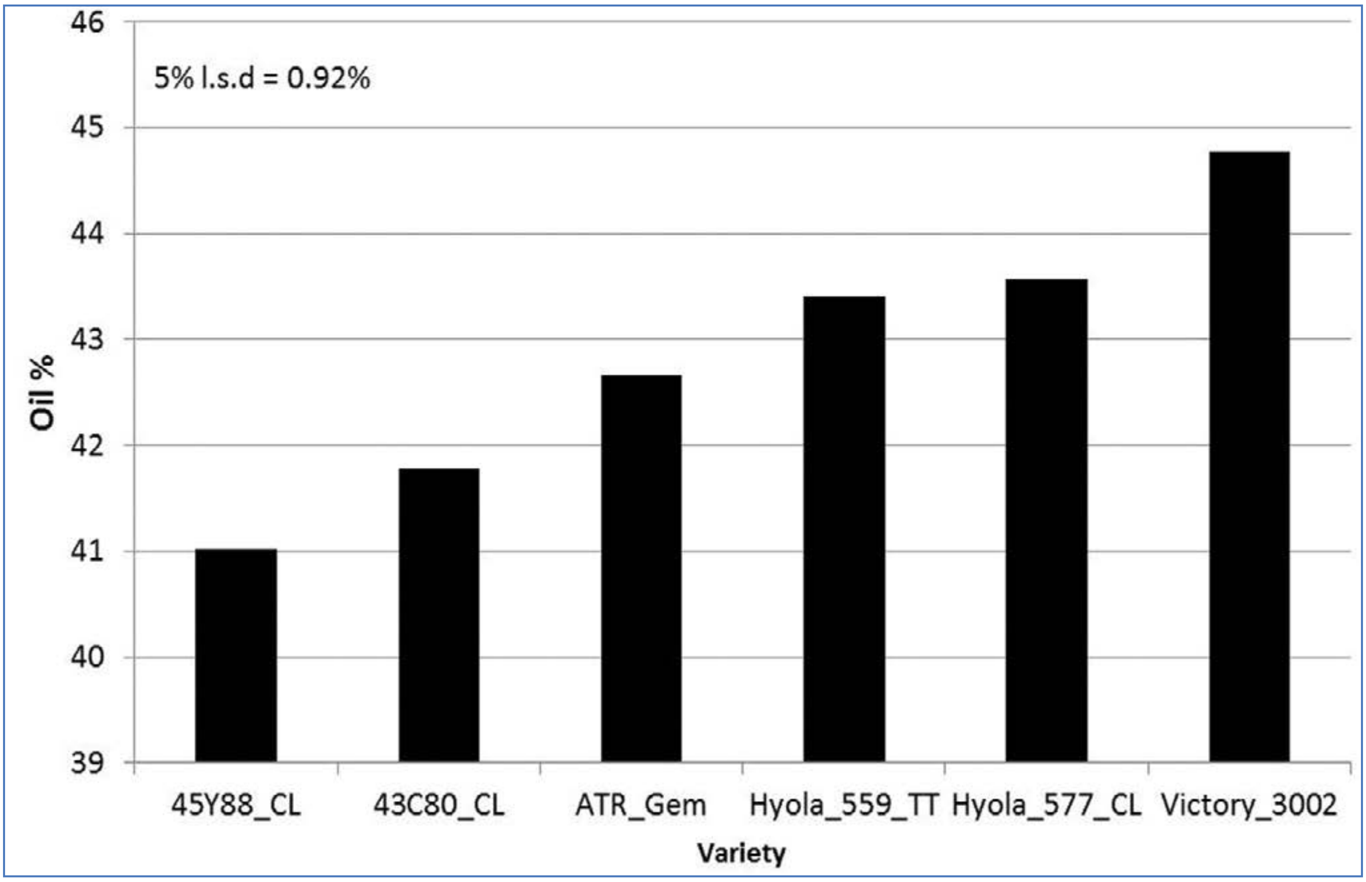

Figure 3: Grain oil concentration of six canola varieties averaged across five nitrogen rates at Canowindra in 2014.

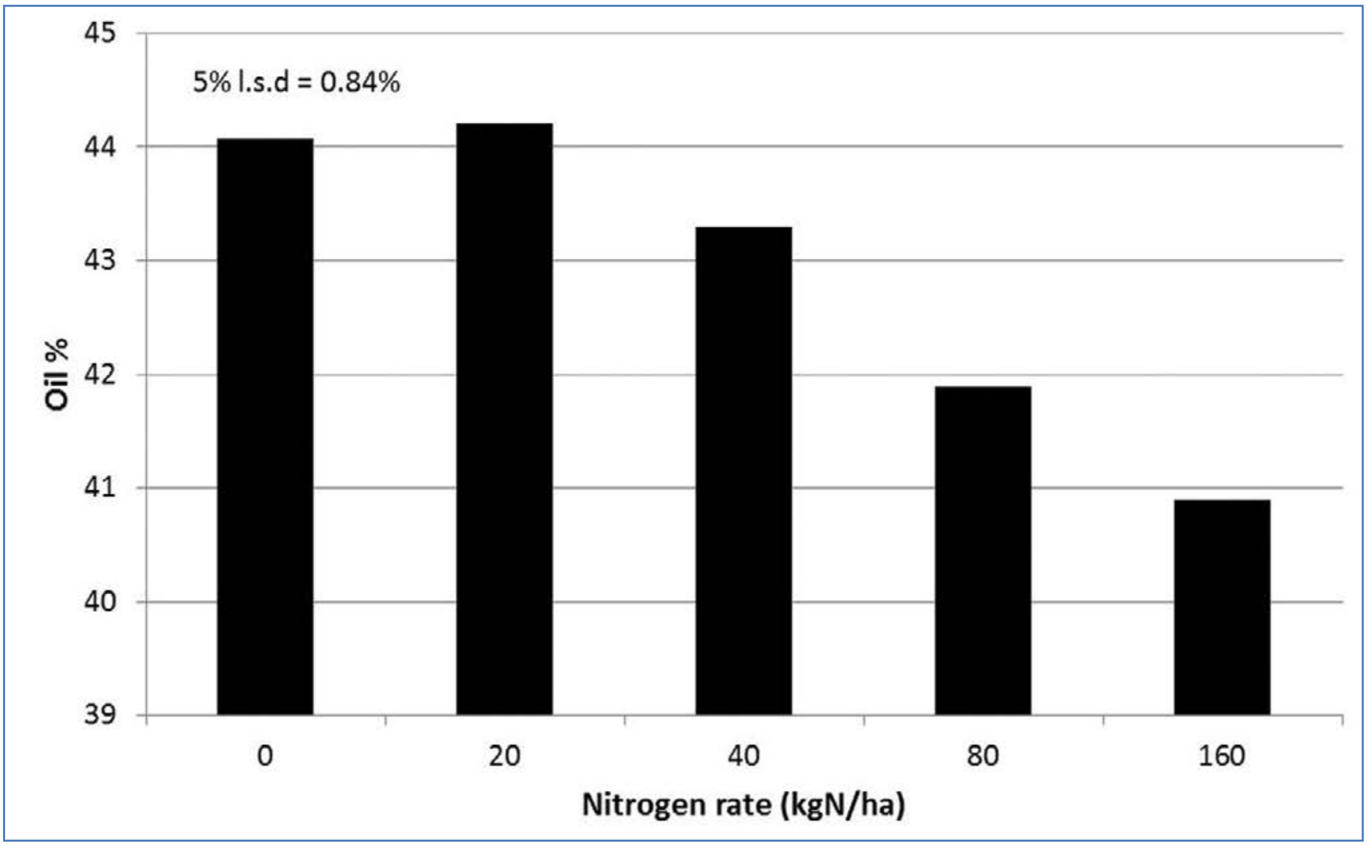

Figure 4: Grain oil concentration of five nitrogen rates averaged across six canola varieties at Canowindra in 2014.

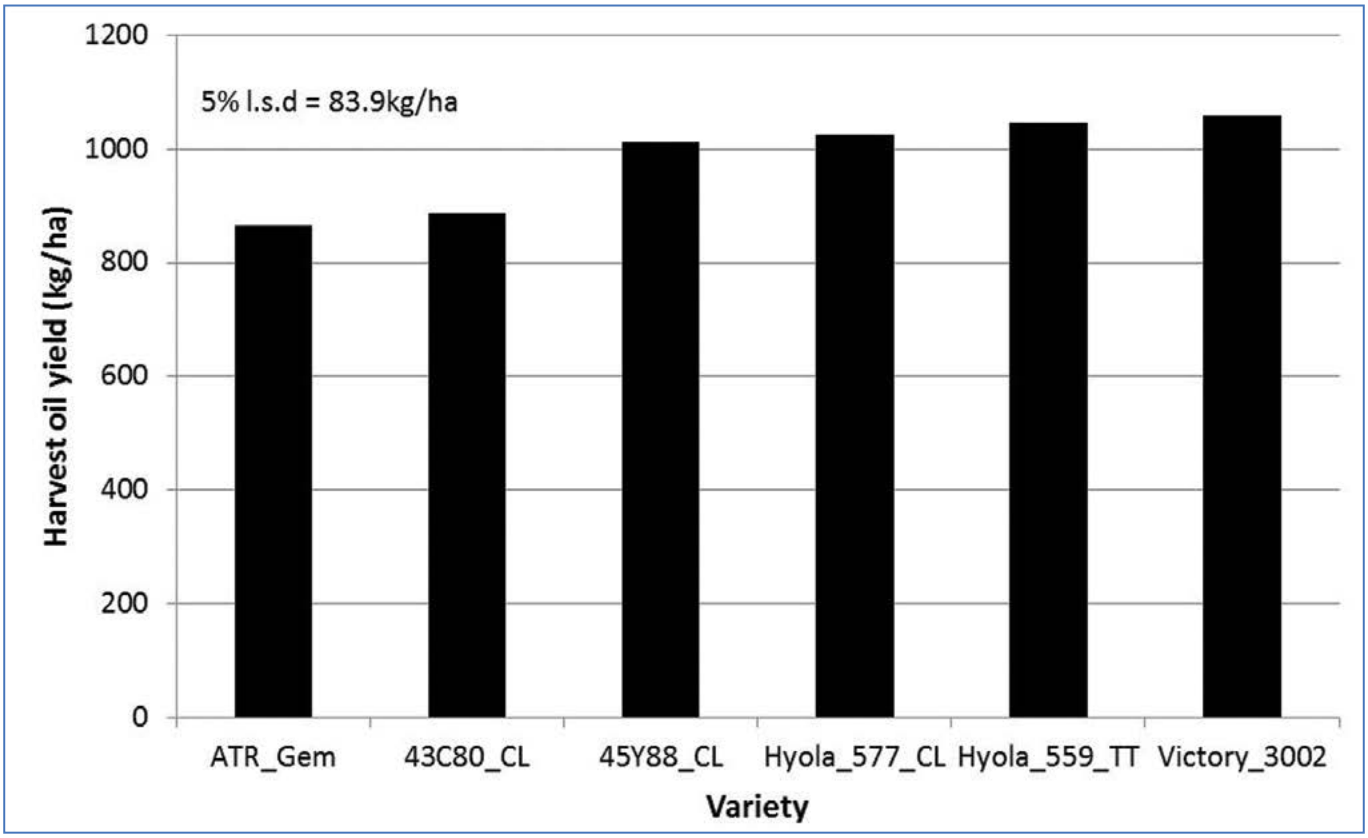

Figure 5: Harvest oil yield of six canola varieties averaged across five nitrogen rates in at Canowindra in 2014.

Summary

There was a 0.44 t/ha grain yield benefit from selecting a Clearfield hybrid (45Y88 CL) over an open-pollinated TT variety (ATR-Gem) in this experiment.

Despite the grain yield response of the hybrid, there was no significant interaction between variety and applied nitrogen. This would suggest that hybrids are more N-use efficient than open-pollinated canola varieties and hence they are better scavengers of N. However this also means that soil N levels will be more depleted following a hybrid canola crop compared to an open-pollinated variety.

Interestingly, oil concentrations decreased as the N fertiliser rate increased. There was a 0.8 percentage point oil concentration decrease with the additional 0.24 t/ha grain yield response from the top performing N rate (40 kg N/ha) treatment. As the N fertiliser rate increased to 80 and 160 kg N/ha, there was a respective oil percentage point decrease of 2.2 and 3.2 with the additional 0.17 and 0.19 t/ha grain yield response.

This trend has been well reported in other studies (Hocking and Stapper, 2001), and was found to be linked to increased moisture stress after flowering and during grain fill. The moisture stress experienced in this experiment was directly related to the additional biomass accumulated as a result of additional nitrogen fertiliser.

Varietal differences in oil concentration were evident in this experiment, with the specialty oil variety Victory V3002 having a significantly higher oil concentration than all other canola varieties. However, when this was converted to total oil harvested there was no significant difference between Victory V3002 and any of the hybrid varieties, whilst there was 0.17 and 0.19 t/ha less oil removed in the open-pollinated varieties, 43C80 CL and ATR-Gem respectively.

Reference

Hocking, P.J. and Stapper. M. (2001). Effects of sowing time and nitrogen fertilizer on canola and wheat, and nitrogen fertilizer on Indian mustard. I. Dry matter production, grain yield, and yield components. *Australian Journal of Agricultural Research* 52:623-634.

Acknowledgements

This experiment is part of the *Variety specific agronomy package* project (DAN00167, 2013–2017), jointly funded by GRDC and NSW DPI.

Thank you to Oliver and Karen Stone for allowing NSW DPI to conduct the experiment on their property 'Brittas' Canowindra NSW.

Support from Lachlan Fertilisers/Delta Agribusiness in providing grain analysis for this experiment, and assistance from Peter Wilson and Neale Coutanche in harvesting the site is gratefully acknowledged.

Effect of sowing date on phenology and grain yield of canola—Ganmain 2014

Rohan Brill and Karl Moore NSW DPI, Wagga Wagga, and Don McCaffery NSW DPI, Orange

Key findings:

- Early sowing exaggerates inherent phenological differences of commercial canola varieties.
- The fast developing 'spring' variety Hyola® 575CL sown 1 April flowered on 12 June. Comparitively, the relatively slow developing 'spring' variety 45Y88 CL and the 'winter' variety Hyola® 971CL flowered on 20 July and 18 September respectively from an April 1 sowing date.
- Highest yields were achieved from 1 April sowing of 45Y88 CL and from 28 April sowing of Hyola® 575CL.

Introduction

Canola sowing date in southern NSW has gradually shifted earlier in response to dry spring conditions and often increased late summer/early autumn rainfall. There has been little evaluation of the varieties and agronomic practices required for early sowing. This experiment assessed the phenology and grain yield response of a selected group of canola varieties across a range of sowing dates with particular emphasis on early sowing. It also aimed to determine the optimum plant population for these sowing dates.

Site details

Soil type	Red clay loam, pH_{Ca} 5.4
Previous crop	Barley, stubble burnt on 30 March
Rainfall	270 mm April–October + 100 mm December–March (2013/14)
Fertiliser	100 kg/ha Urea pre-drill + 100 kg/ha MAP at sowing + 100 L/ha UAN on 29 May

Treatments

Varieties	ATR-Gem Hyola® 559TT Hyola® 575CL Hyola® 971CL 44Y87 CL 45Y88 CL
Sowing dates	TOS 1 - 1 April TOS 2 - 15 April TOS 3 - 28 April TOS 4 - 13 May
Target plant population	All varieties at 45 plants/m^2 Also Hyola® 575CL, 44Y87 CL and 45Y88 CL at 15 plants/m^2

Results

There were large differences observed in the phenology of the spring varieties in this experiment. Hyola® 575CL reached 50% flowering (date where 50% plants have one open flower) on 12 June, compared with 44Y87 CL and 45Y88 CL which reached 50% flowering on 20 July, 38 days later (*Table 2*). The winter variety Hyola® 971CL sown on 1 April reached 50% flowering on 18 September, 98 days after Hyola® 575CL sown on 1 April.

As sowing was delayed into mid-May, the difference in time taken to reach 50% flowering was reduced, whereby Hyola® 575CL sown on 13 May was only six days quicker than 44Y87 CL and 45Y88 CL and 27 days quicker than Hyola® 971CL.

The highest grain yield in this experiment (and the only treatments greater than 2 t/ha) were 1 April sown 45Y88 CL and 28 April sown Hyola® 575CL (*Table 1*). Hyola® 575CL suffered a yield penalty from early sowing which was due partly to frost damage but also possibly to its rapid development resulting in reduced biomass production and reduced yield potential. Target biomass of canola at flowering is approximately 5 t/ha. Hyola® 575CL accumulated only 3.30 t/ha when sown on 1 April (*Table 1*).

Hyola® 971CL, ATR-Gem and Hyola® 559TT were significantly lower yielding than the hybrid Clearfield varieties at all sowing dates (TT varieties not harvested from the 13 May sowing date due to establishment issues). The TT varieties generally did not produce sufficient vegetative biomass while the winter variety Hyola® 971CL produced ample biomass but flowered

Table 1: Biomass at 50% flowering (50% of plants with one open flower) of six canola varieties sown at four sowing dates at Ganmain in 2014.

Variety	Biomass at flowering (t/ha)			
	TOS 1 - 1 Apr	TOS 2 - 15 Apr	TOS 3 - 28 Apr	TOS 4 - 13 May
44Y87 CL	5.06	7.04	6.56	2.93
45Y88 CL	5.54	7.26	6.48	2.94
ATR-Gem	3.58	4.72	3.80	-
Hyola® 559TT	4.38	4.45	4.03	-
Hyola® 575CL	3.30	5.57	5.90	3.76
Hyola® 971CL	9.05	8.18	4.90	4.54
l.s.d. (p=0.05)	1.03			

Table 2: The effect of sowing date on phenology and grain yield of six canola varieties at Ganmain in 2014.

Variety	Grain yield (t/ha)				Date of 50% flowering			
	TOS 1 - 1 Apr	TOS 2 - 15 Apr	TOS 3 - 28 Apr	TOS 4 - 13 May	TOS 1 - 1 Apr	TOS 2 - 15 Apr	TOS 3 - 28 Apr	TOS 42 - 13 May
44Y87 CL	1.76	1.89	1.73	0.90	20 Jul	11 Aug	27 Aug	12 Sep
45Y88 CL	2.07	1.88	1.67	1.11	20 Jul	6 Aug	26 Aug	12 Sep
ATR-Gem	1.27	1.21	1.34	-	30 Jun	31 Jul	8 Aug	-
Hyola® 559TT	1.52	1.41	1.39	-	5 Jul	2 Aug	15 Aug	-
Hyola® 575CL	1.60	1.81	2.13	1.29	12 Jun	20 Jul	15 Aug	6 Sep
Hyola® 971CL	1.41	1.46	1.36	0.69	18 Sep	25 Sep	2 Oct	3 Oct
l.s.d. (p=0.05)	0.29							

and filled pods late in warmer, drier conditions of late spring.

The interaction between sowing date and plant population was also investigated in this experiment but only on Hyola® 575CL, 44Y87 CL and 45Y88 CL. There was a significant interaction between sowing date and plant population (*Table 3*), with 45 plants/m² population having relatively stable yield across sowing dates (and all varieties) for TOS 1 to TOS 3 compared to 15 plants/m², which showed a yield decline as sowing was delayed.

Summary

This experiment showed that similar to other crops such as wheat and barley, the sowing time of canola needs to be closely matched with the phenology of each variety to optimise grain yield. The experiment also highlighted significant differences in the phenology of current commercial canola varieties, even within varieties of the same maturity groups. These differences in phenology will be further quantified to guide future decisions on sowing date and variety choice.

Varietal phenology is important in order to guide management decisions to minimise plant stress at critical reproductive periods, but this experiment highlighted how varietal phenology can have a significant effect on vegetative biomass production and yield potential.

The experiment showed that a lower plant population can be acceptable in an early sowing situation; but a higher plant population was significantly higher yielding as sowing was delayed. The lower plant population from the early sowing would be slightly more profitable due to lower seed cost; however the extra seed cost of the higher population would likely have been recovered by the extra grain yield for the later sowing dates.

Table 3: The interaction between plant population and sowing date, averaged across three canola varieties at Ganmain in 2014.

Plant population	Grain yield (t/ha)			
	TOS 1 - 1 Apr	TOS 2 - 15 Apr	TOS 3 - 28 Apr	TOS 4 - 13 May
15 plants/m²	1.79	1.54	1.36	0.75
45 plants/m²	1.81	1.86	1.84	1.11
l.s.d. (p=0.05)	0.18			

Acknowledgements

This experiment is part of the *Optimised canola profitability* project (CSP00187, 2014–2019) jointly funded by GRDC and NSW DPI.

Thanks to Dennis and Dianne Brill ‘Erinvale’ Ganmain for their cooperation with this experiment. Thanks also to Technical Assistants involved in this experiment, Warren Bartlett, Greg McMahon, Russell Pumpa and Sharni Hands.

Effect of seed size and seeding rate on performance of a hybrid and an open-pollinated canola variety—Wagga Wagga 2014

Rohan Brill and Karl Moore NSW DPI, Wagga Wagga

Key findings

- There was no effect of seed size on canola establishment in this experiment.
- There were early vigour and grain yield benefits from:
  - planting the hybrid variety;
  - increasing seeding rate from 25 to 50 seeds/m^2; and
  - sowing 'large' seed.
- There was a strong correlation between early dry matter production and final grain yield.

Introduction

Research on canola seed quality has shown that sowing larger seed (>2 mm diameter) can improve crop establishment, especially in challenging conditions such as planting deeper than usual to access moisture. This experiment was conducted to expand on previous findings and determine if the establishment benefits of planting larger seed resulted in benefits on early vigour and grain yield.

Site details

Soil type	Silty loam, pH$_{Ca}$ 5.9
Sowing date	24 April 2014
Previous crop	Wheat, stubble burnt prior to planting
Rainfall	280 mm April-October + 140 mm December 2013–March 2014
Fertiliser	100 kg/ha MAP at sowing + 100 kg/ha sulfate of ammonia (10 June) + 100 kg/ha urea (10 June) + 100 kg/ha urea (4 July)

Treatments

2 varieties	43C80 CL (open-pollinated) 44Y84 CL (hybrid)
2 seed rates	25 and 50 seeds/m^2
3 seed sizes	see *Table 1*

Table 1: Screen size used and resultant seed size of two varieties sown in the seed quality experiment.

Variety	Seed size	Screen size (mm)	Seed weight (g/1000 seeds)
43C80 CL	Small	< 1.8	3.06
	Medium	1.8 - 2	3.68
	Large	> 2	4.82
44Y84 CL	Small	< 2	5.40
	Medium	2 - 2.2	7.51
	Large	> 2.2	8.74

Results

There were no significant differences between the treatments for canola establishment, most likely because the experiment was planted into ideal moisture conditions, approximately 20 mm deep.

There were no interactions between any of the treatments in this experiment for either early biomass production or grain yield, so only the main treatment effects of variety choice, seed rate and seed size are reported here.

Biomass samples were taken at 8 to 10 leaf to assess early vigour of the treatments (*Table 2*). The results included:

- The hybrid variety 44Y84 CL produced 64% more biomass than the OP variety 43C80 CL.
- Planting 50 seeds/m^2 produced 25% more biomass than planting 25 seeds/m^2.
- Planting 'large' seed produced 40% more biomass than planting 'small' seed.

Table 2: Effect of variety, seed size and seed rate on early dry matter production of canola at Wagga Wagga 2014.

Variety	Early dry matter (t/ha)
43C80 CL	0.82
44Y84 CL	1.34
l.s.d. (p=0.05)	0.12
Seed size	
Small	0.90
Medium	1.08
Large	1.26
l.s.d. (p=0.05)	0.14
Seed rate (plant/m^2)	
25	1.20
50	0.96
l.s.d. (p=0.05)	0.12

The experiment was harvested for grain yield in November (*Table 3*). The main treatment effects on grain yield were:

- The hybrid variety 44Y84 CL was 43% higher yielding than the OP variety 43C80 CL.
- Planting 50 seeds/m^2 produced 12% higher grain yield than planting 25 seeds/m^2.

- Planting 'large' seed produced 12% higher grain yield than planting 'small' seed.

Summary

This experiment showed both an early vigour and a grain yield benefit from selecting a hybrid variety, increasing the seeding rate and sowing 'large' seed. Even allowing for the major frost events through August and the dry spring at this site, there was still a strong correlation between early dry matter production (early vigour) and grain yield (*Figure 1*).

A secondary benefit of early vigour is increased competition with weeds which may reduce reliance on herbicides for weed control.

Acknowledgements

This experiment was part of the *Optimised canola profitability* project (CSP00187, 2014–2019) jointly funded by GRDC and NSW DPI.

Thanks to the Gollasch family for their cooperation with this experiment. Thanks to Phil Armstrong and the Wagga Wagga Crop Evaluation Unit for conducting this experiment and to Technical Assistants involved in this experiment, Warren Bartlett, Greg McMahon, Russell Pumpa and Sharni Hands.

Table 3: Effect of variety, seeding size and seed rate on grain yield of canola at Wagga Wagga 2014.

Variety	Grain yield (t/ha)
43C80 CL	1.18
44Y84 CL	1.68
l.s.d. (p=0.05)	0.08
Seed size	
Small	1.35
Medium	1.43
Large	1.51
l.s.d. (p=0.05)	0.10
Seed rate (plant/m²)	
25	1.35
50	1.51
l.s.d. (p=0.05)	

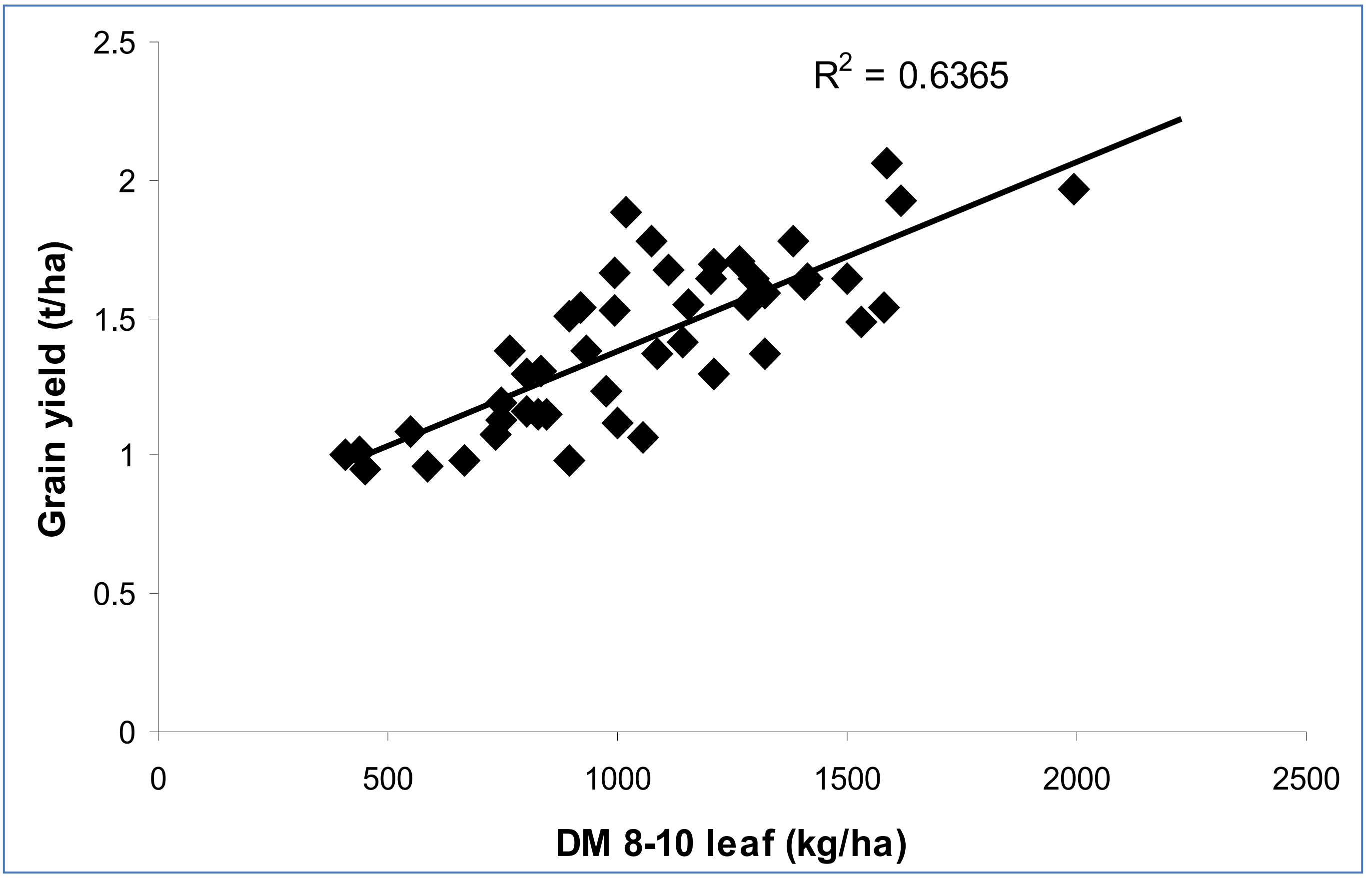

Figure 1: The effect of early dry matter production on subsequent grain yield at Wagga Wagga in 2014.

The effect of variety, time of sowing and plant population on high-yielding irrigated canola production

Tony Napier NSW DPI, Yanco, Luke Gaynor, Deb Slinger, Cynthia Podmore NSW DPI, Wagga Wagga and Dr Neroli Graham NSW DPI, Tamworth

Key findings

- Variety selection is a major driver of high yielding irrigated canola production.
- Time of sowing and nitrogen timing did not significantly affect canola grain yield in the first year trials.
- The variety and time of sowing interaction had a significant effect on canola grain yield.

Introduction

Canola can be an important crop for irrigation growers in the Riverina. However, growers will only include canola in their rotation if high yields can be achieved consistently and commodity prices are sufficient.

With low water allocations and high irrigation costs, growers need to achieve high yields every season and produce 'more crop per drop'. The *Southern irrigated cereal and canola varieties achieving target yields* project aims to identify the most suitable canola varieties for irrigated farming systems in the Riverina and the best management practices required to achieve high yields.

The first of three seasons of trials as part of the project was conducted in 2014. A further two years of trials will be conducted to validate these initial findings and develop recommendations in the form of best management practice guides and variety specific agronomy packages (VSAPs). Similar trials are being replicated throughout the irrigation areas of south eastern Australia.

Site details

Location	Leeton
Trial period	Winter crop growing season 2014
Manager	Tony Napier
Soil type	Self-mulching medium clay soil
Previous crop/s	Barley
Sowing date/s	9 and 24 April
Planter	Six rows per plot, row spacing 30 cm
Harvest date/s	12–17 November
Fertiliser	Base of 400 kg/ha Superfect, 150 kg/ha MAP, 150 kg/ha Gran-Am and 125 kg/ha urea. Topdressed with 150 kg/ha urea
Irrigation	One autumn pre-irrigation plus three spring irrigations

Treatments

1. Variety

Twelve canola varieties were evaluated. They were:

43C80 CL	44Y87 CL	Hyola® 450TT
44Y84 CL	Hyola® 50	ATR-Gem
45Y88 CL	Hyola® 559TT	ATR-Bonito
Hyola® 577CL	AV-Garnet	Victory V3002

2. Time of sowing

The two time of sowing treatments evaluated were 9 April (early sown) and 26 April (late sown).

3. Plant population

The two established plant populations evaluated were 30 established plants/m^2 (low) and 50 established plants/m^2 (high).

Figure 1: Aerial view of the canola trials (and wheat trials in foreground) at Leeton 2014.

Results

Variety

There were significant varietal differences in grain yield. Highest grain yields were achieved by the varieties 45Y88 CL and Hyola® 50, with 4.21 t/ha and 4.16 t/ha respectively (*Figure 2*). These grain yields were 20% greater than the lowest yielding variety 44Y84 CL and 43C80 CL which yielded 3.15 t/ha and 3.31 t/ha respectively (*Figure 2*).

Plant population

Plant population did not have any significant effect on yield in this experiment. The low plant population treatment averaged 3.69 t/ha which was statistically

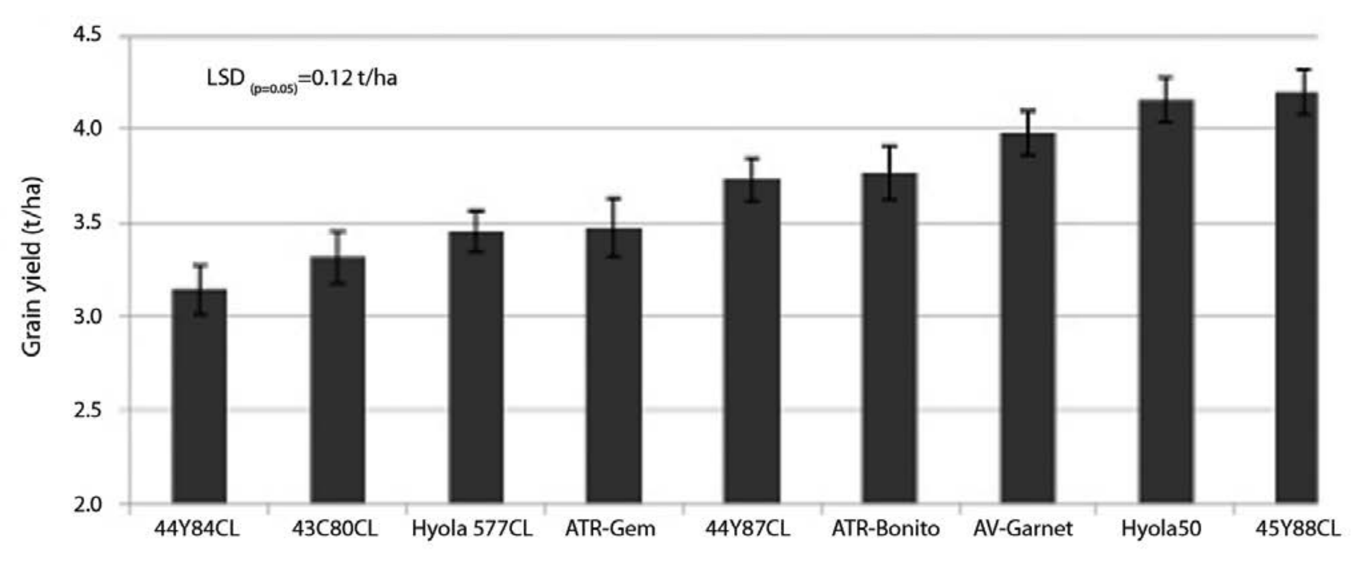

Figure 2: Grain yield of irrigates canola varieties at Leeton 2014.

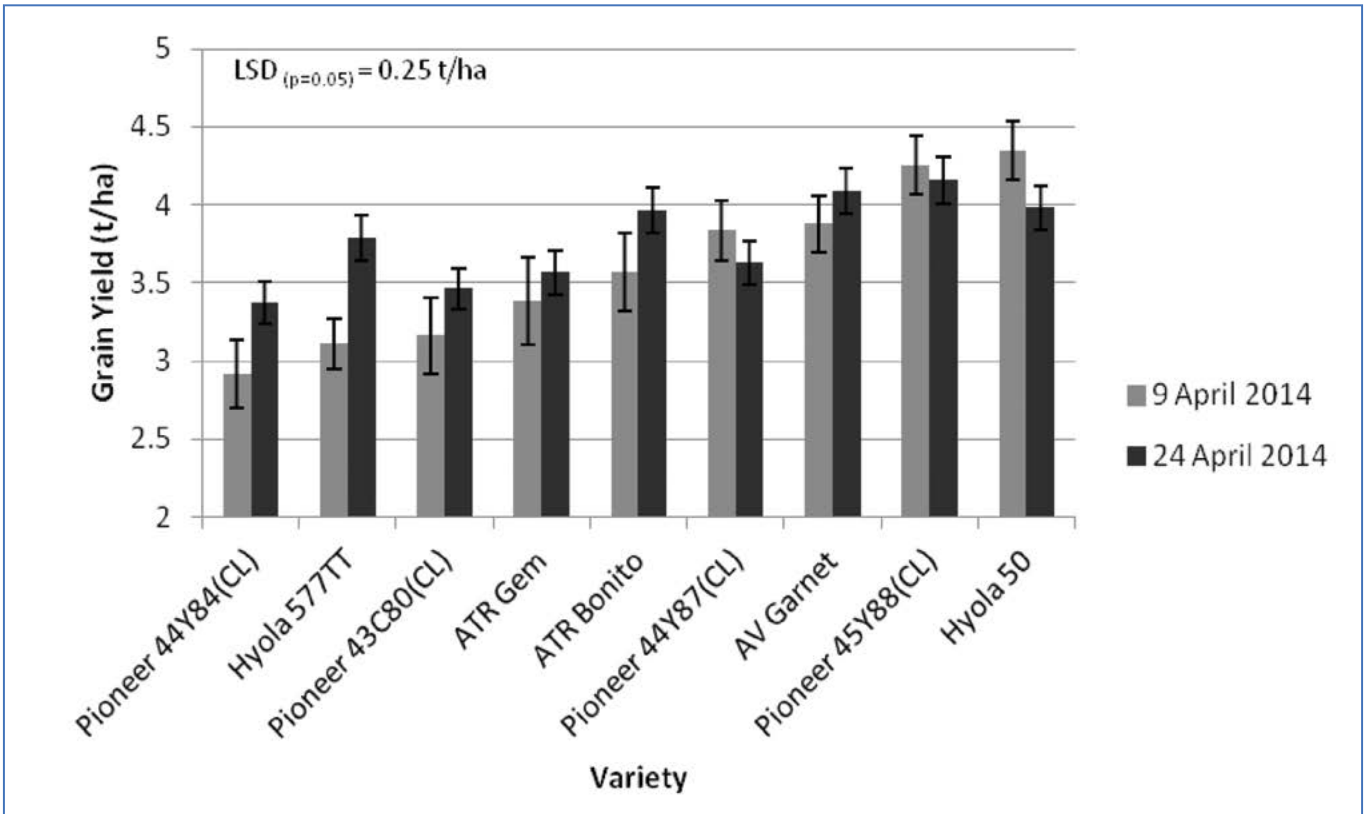

Figure 3: Grain yield (t/ha) of each variety at the two sowing dates at LFS in 2014.

similar to the high plant population treatment which averaged 3.66 t/ha. Some varieties including 43C80 CL and Hyola® 577CL had slightly increased grain yield at the higher plant population of 50 plants/m^2 while other varieties such as 45Y88 CL and AV-Garnet had a reduction in yield with increasing plant population.

Time of sowing

Delaying the sowing time of canola at Leeton from 9 April to 24 April had no effect on grain yield. The later sowing time had the higher grain yield with an average of 3.73 t/ha but was statistically similar to the earlier sowing time with an average grain yield of 3.62 t/ha.

The first sowing date had significantly more frost damage than the second sowing date but final grain yields were similar for both time of sowing treatments. The sowing time effect requires further investigation outside the event of frost as it is likely that there would be yield differences across sowing times.

The variety by time of sowing interaction had a significant effect on grain yield, with Hyola® 577CL increasing from 3.1 to 3.8 t/ha when sown at the later sowing date of 24 April. Varieties such as 44Y84 CL,

Figure 4: Canola time of sowing experiment at Leeton 2014.

43C80 CL and ATR-Bonito had higher grain yields when sown on 24 April (*Figure 3*). However, 44Y87 CL and Hyola® 50 showed a decrease in grain yield when sowing was delayed from early April to late April (*Figure 3*).

Summary

This experiment demonstrated that a grain yield of 4 t/ha is achievable for irrigated canola and that correct variety selection is a key driver of achieving high yields. Hyola® 50 and 45Y88 CL both yielded over 4 t/ha, when yield results were averaged across treatments. AV-Garnet and 44Y87 CL also performed with average yields of 3.88 t/ha and 3.84 t/ha respectively.

Plant density was shown to impact final yield but the results were not statistically significant this season. More work is needed to determine the effect of sowing date and time of nitrogen application (not discussed in this article) on yield and grain quality.

The research trials will be conducted for another two years (2015 and 2016). The research outcomes of the project will also assist with the development of three tools for growers and advisers (due for completion in 2017):

1. *Irrigated wheat: best practice guidelines in southern irrigated cropping systems* manual
2. *Irrigated canola: best practice guidelines in southern irrigated cropping systems* manual
3. *Variety specific agronomy packages* (VSAPs) for each research location.

Acknowledgements

This research is part of the *Irrigated cereal and canola varieties achieving target yields* project (DAN00198, 2014–2017) jointly funded by GRDC and NSW DPI.

The support of Glenn Morris, Paul Morris and Patrick Dando for assistance with management, field assessments and data collection is gratefully acknowledged. We would also like to gratefully acknowledge Ken Brain for allowing us to establish a nitrogen experiment at Coleambally on his property.

Monitoring sclerotinia stem rot development in commercial canola crops in southern NSW

Dr Kurt Lindbeck and Audrey Leo NSW DPI, Wagga Wagga

Key findings

- Sclerotinia stem rot is a very sporadic disease in southern NSW. Variations in the level of disease can occur between districts, between years and between paddocks.
- The best indicators of a high sclerotinia risk district are a high intensity of canola production, frequent development of sclerotinia stem rot and reliable rainfall during flowering.
- Preliminary results indicate prolonged periods (at least 48 hours) of relative humidity above 95% can trigger sclerotinia stem rot development.
- A high level of petal infestation with Sclerotinia ascospores does not guarantee development of stem rot.

Introduction

In 2013 commercial canola crops in sclerotinia prone districts were closely monitored in southern NSW to increase our understanding of the epidemiology of sclerotinia stem rot. Six commercial crops in districts where the disease is known to frequently occur were specifically chosen to identify the 'trigger points' that lead to sclerotinia stem rot development. In 2014, the opportunity was taken to repeat the monitoring exercise to increase our understanding of the disease.

The outcome of this work is to improve our understanding of the interaction between the pathogen life cycle, the host crop and the prevailing environmental conditions with the view to developing a disease prediction model that could be used by industry.

Methods

In 2013 and 2014, six commercial canola crops were chosen located in districts with a high sclerotinia risk. These districts feature high yield potential with reliable spring rainfall, extended flowering periods for canola and frequent outbreaks of sclerotinia. The crops were located at Howlong, Alma Park (south-west of Henty) and Morven (east of Culcairn) and two crops located east of Cootamundra.

Each crop had half hourly recordings of humidity and temperature using data loggers located within the crop canopy. The nearest BOM weather station was used to access rainfall records. Weekly observations were taken within each crop from stem elongation to maturity, these included scouting for apothecia development (the fruiting structure of the fungus that releases air-borne ascospores), sampling of petals for levels of ascospore infestation and counts for the level of plant infection within the crop. The type of infection (leaf, lateral branch or main stem) was also recorded.

Results

2013 – Results and Observations

Stem rot developed in each of the monitored crops. Early flowering crops, mild winter temperatures and frequent rainfall events encouraged early development of the disease.

Apothecia were observed in all crops except Howlong, indicating the presence of ascospores and potential for petal infection. Sampling of petals confirmed the presence of ascospores on petals.

Combining weather recordings and observations within the crop allowed disease epidemics to be graphed (*Figure 1*). Relationships were observed between environmental conditions and development of the disease.

As an example from the crop at Howlong in *Figure 1*, a relationship can be observed between relative humidity (RH), rainfall and stem rot development. From knowledge of the biology of the pathogen a prolonged period of at least 95% RH is needed for ascospores to germinate and colonise petals and senescent tissue. This occurred twice: 22/23 August and 16/17 September. These infection events were also followed up with rainfall, which allowed infected tissue to fall into a wet crop canopy and adhere to stems. Approximately two weeks later the first symptoms of stem rot appeared within the crop after the initial infection event. The second infection event added to the existing level of infection and allowed further development of the disease. The final level of stem infection counted was 50% within the crop at the end of October.

In contrast, one of the crops at Cootamundra developed much reduced levels of stem rot (*Figure 2*; note change of scale).

Only one infection event occurred in the crop on the 9/10 September, with rainfall not occurring for several days. This mismatching of high RH and rainfall around the 9/11 September most likely resulted in reduced opportunities for stem rot to develop, which peaked at around 5% levels of plant infection in crop.

2014 – Results and Discussion

Six commercial crops were monitored for sclerotinia stem rot development in 2014. Of these crops only the four crops located south of Wagga Wagga, at Howlong, Alma Park and Morven, developed significant levels of disease.

Apothecia were observed in all four crops from the commencement of flowering and petal testing showed high levels (over 90%) of petal infestation by sclerotinia ascospores for most of the flowering period.

Using a similar approach to 2013, humidity, rainfall and temperature data was plotted against plant infection observations made during the growing season to identify infection events. *Figure 3* indicates two probable infection events (high humidity for at least 48 hours and rainfall) in a canola crop monitored at Alma Park. It appears that two infection events occurred on the 9/10 September and 24/25 September. It is interesting to note that the highest levels of branch and stem infection were observed after flowering had finished and daily average humidity was falling, but following a number of rainfall events. Observations within the crop suggest that infected senescent leaves were also important in the development of stem lesions later in the season after flowering had finished. Final

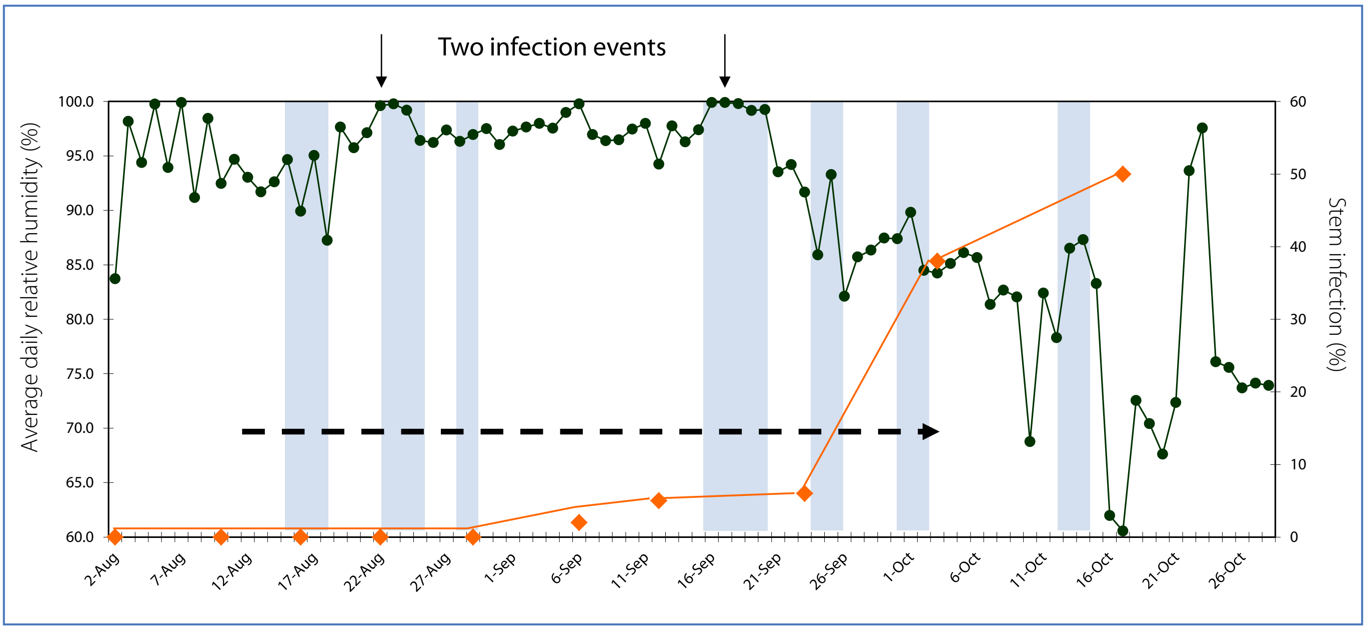

Figure 1: Relationship between relative humidity (circle line) and level of sclerotinia stem rot (diamond line) at Howlong in 2013. Flowering period is represented by the dashed line. Rainfall events are represented by the pale columns.

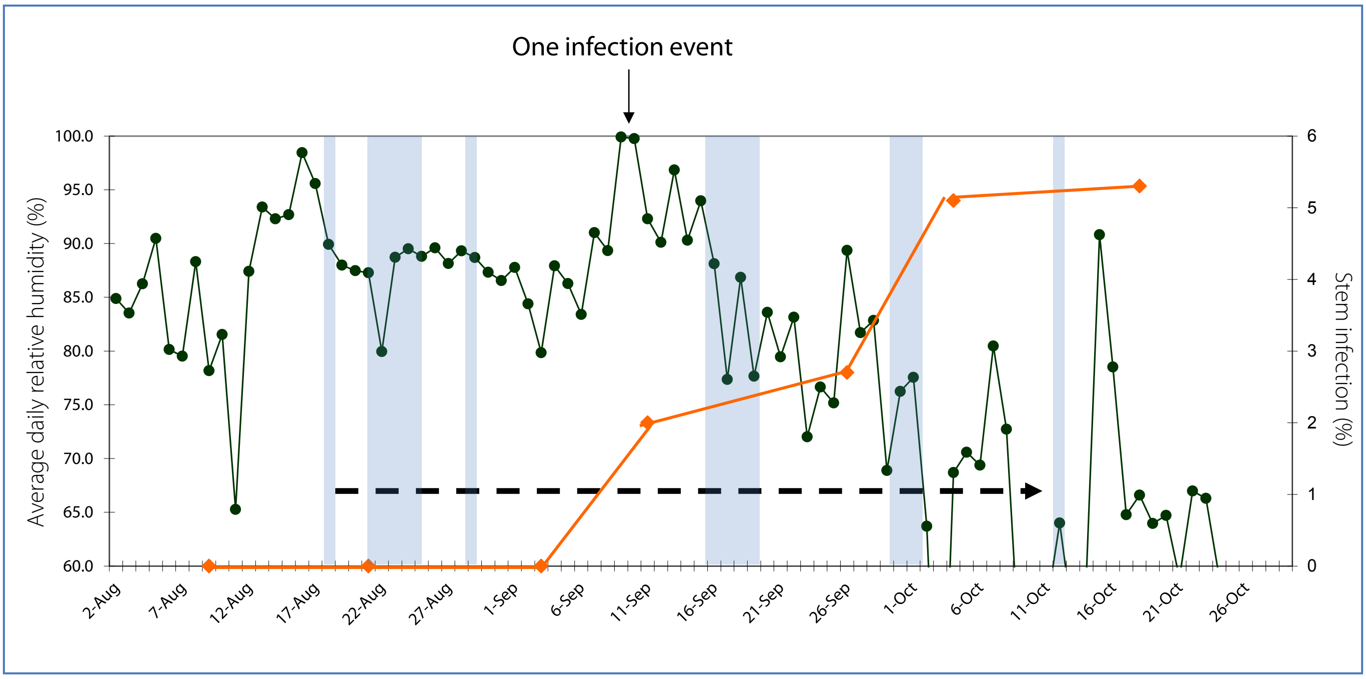

Figure 2: Relationship between relative humidity (circle line) and level of sclerotinia stem rot (diamond line) at Cootamundra in 2013. Flowering period is represented by the dashed line. Rainfall events are represented by the pale columns.

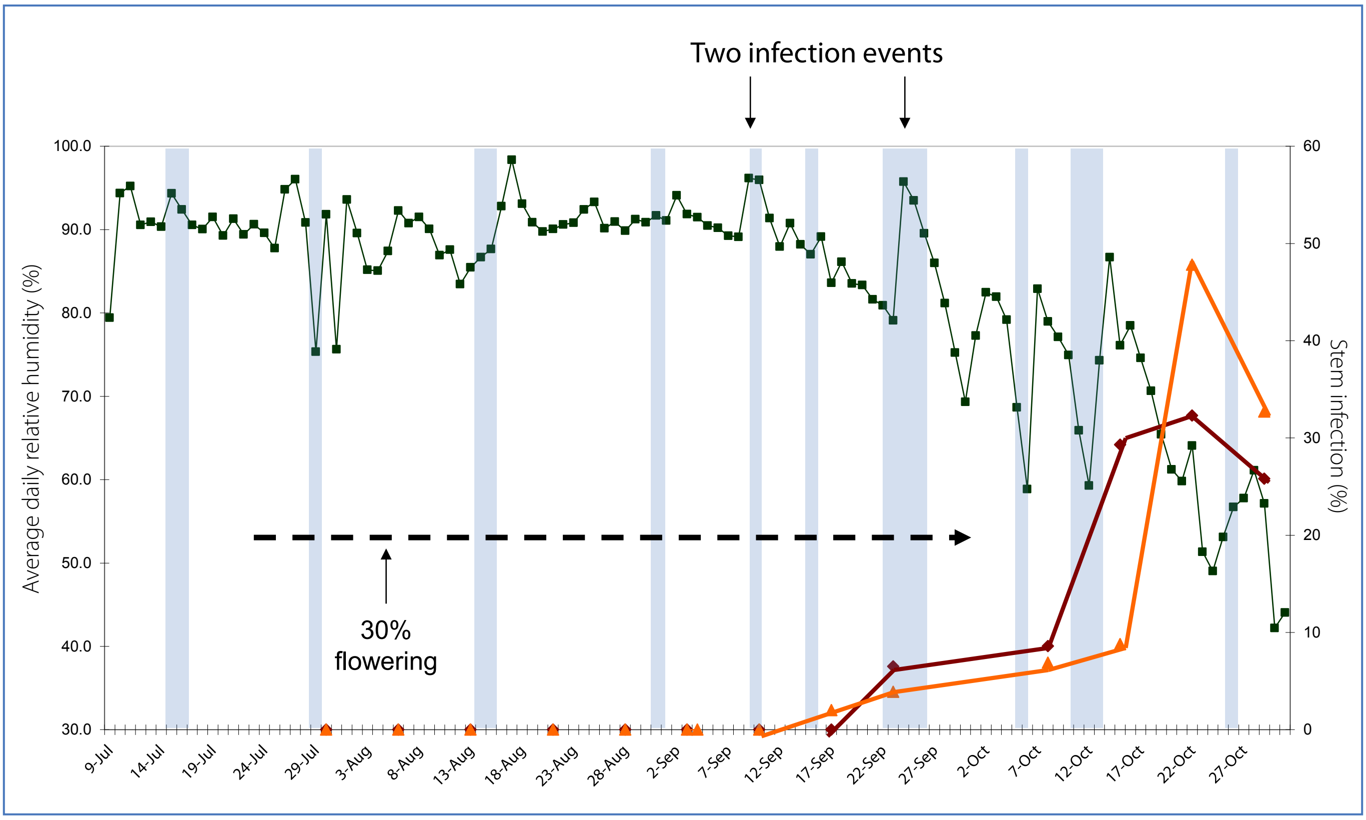

Figure 3: Relationship between relative humidity (circle line) and level of sclerotinia stem rot at Alma Park in 2014. The triangle line represents the level of branch infection from sclerotinia and the diamond line represents main stem infection. Flowering period is represented by the dashed line. Rainfall events are represented by the pale columns.

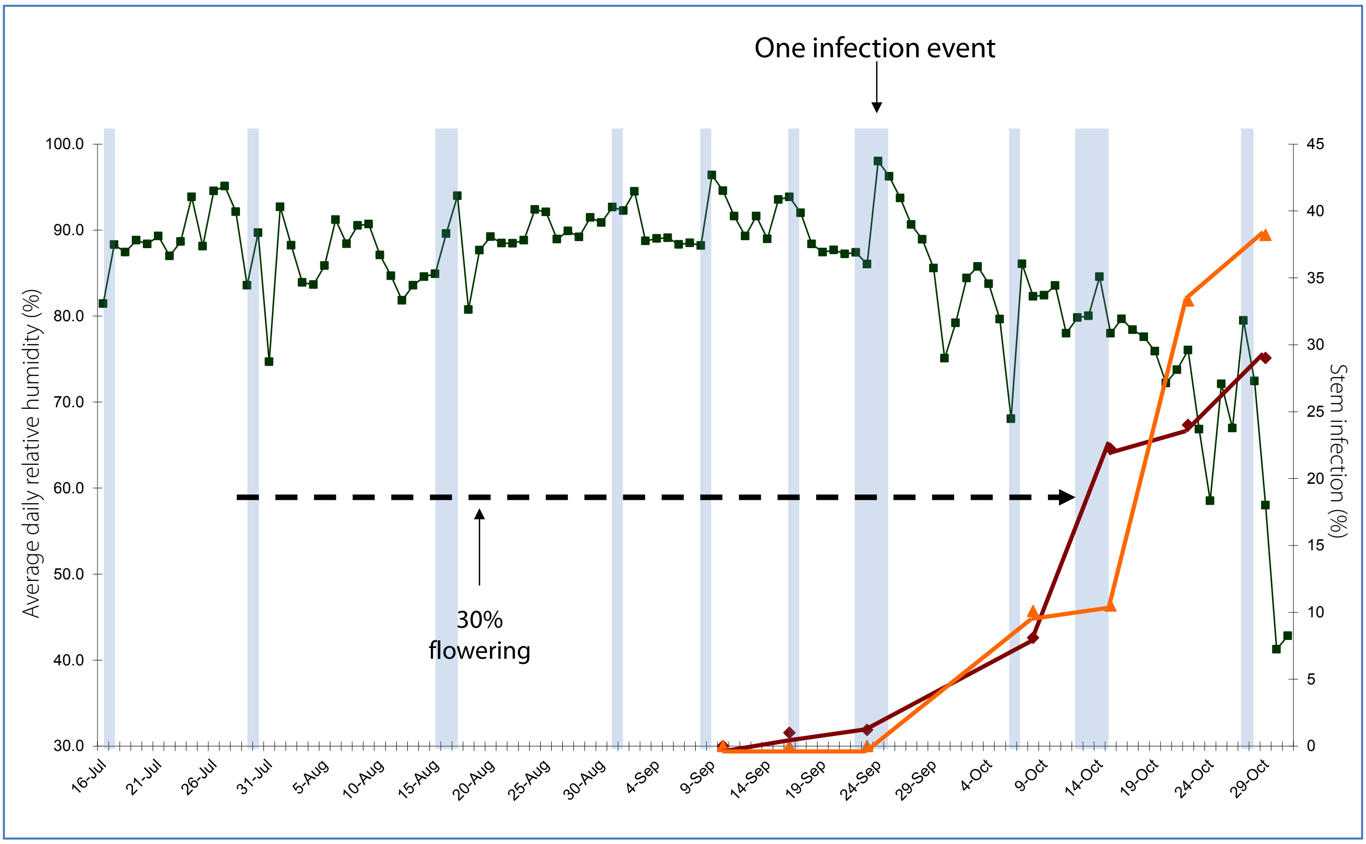

Figure 4: Relationship between relative humidity (circle line) and level of sclerotinia stem rot at Morven in 2014. The triangle line represents the level of branch infection from sclerotinia and the diamond line represents main stem infection. Flowering period is represented by the dashed line. Rainfall events are represented by the pale columns.

main stem infection levels were approximately 30% on average, with branch infections observed on 40% of plants within the crop.

As a comparison, *Figure 4* depicts the progression of sclerotinia stem rot in a crop of canola at Morven in 2014. The infection that occurred at Alma Park on 9/10 September did not appear to occur at the Morven site, with a single infection event on the 24/25 September. However, similar to the Alma Park crop, the highest levels of stem and branch infection occurred after the completion of flowering, and following a number of rainfall events. Despite the crop only being exposed to one infection event, the level of infection within the crop was still significant at approximately 30% of plants with main stem infection and 38% with branch infection by maturity.

Summary

Results from 2013 and 2014 crop observations validate the strong relationship between the duration of high humidity (at least 95% for 48 hours), rainfall events, and development of stem rot symptoms. Petal testing in 2013 and 2014 indicated that the presence of fungal inoculum (as viable ascospores) was not limiting in those crops monitored, with petal infestation levels above 90% for most of the flowering period. Even after flowering had completed, subsequent infection of leaves enabled stem infection opportunities to continue.

After two years of observations results are indicating the major driver in the development of sclerotinia stem rot in southern NSW is prolonged (48 hours) durations of high humidity and rainfall. These events provide sufficient leaf wetness periods for the germination of ascospores and infection of petals and leaves. The crop observations also indicate that only one infection event is required to trigger development of significant levels of disease in crop, with follow up rainfall events promoting further symptom development.

Note: This is an industry summary provided pre-publication. Further information and analysis will be published at a later date.

Acknowledgements

*The National canola pathology*p project (UM0051, 2013–18); the *National pathogen modelling* project (DAW00228, 2013–18); and the *Improving grower surveillance, management, epidemiology knowledge and tools to manage crop disease in southern NSW* (DAN00177, 2013–18). These research projects are jointly funded by GRDC and NSW DPI and aim to reduce the impact of crop diseases.

Technical assistance was provided by Tom Thompson.

Effect of nitrogen application and seeding rate on grain yield and protein concentration of wheat—Merriwagga 2013

Barry Haskins AgGrow Agronomy and Research
Dr Peter Martin and Karl Moore NSW DPI, Wagga Wagga

Key findings

- Increasing the sowing rate from 20 kg/ha to 40 kg/ha increased grain yield by 0.4 t/ha.
- The predrilled application of 50 kg N/ha increased grain yield from 1.1 t/ha (nil N) to 2.5 t/ha. The 100 kg N/ha rate increased grain yield by a further 0.4 t/ha.
- EGA_Gregory, Spitfire and Suntop were the highest yielding varieties.
- The nitrogen treatments did not increase grain protein concentration above the nil N treatment for any of the applied N rates.

Introduction

Investment into nitrogen application can be risky for growers in lower rainfall areas, however, the rewards can be significant in certain situations. With an increase in cropping intensity and only a small area of pulse crops sown, soil nitrogen supplies are generally low across the southern region.

The aim of this experiment was to determine the effect of nitrogen application rates and seeding rates on commercially available wheat varieties.

Site details

Soil type	red sandy loam
Pre-sowing available N	96.6 kg/ha (0–90 cm)
Previous crop	wheat (2012 and 2011)
Sowing date	29 April 2013
Soil moisture	approximately 40 cm of moist soil
In-crop rainfall	186.5 mm
Starter fertiliser	60 kg Superfect
Harvest date	7 November 2013

Treatments

6 wheat varieties	EGA_Gregory, Elmore CL PLUS, Livingston, Spitfire, Suntop, Sunvale
4 nitrogen rates	0 kg, 50 kg, 100 kg and 150 kg/ha (pre-drilled)
2 seeding rates	20 kg/ha and 40 kg/ha

Results

Grain yield

EGA_Gregory, Spitfire and Suntop were the highest yielding varieties in this experiment (*Figure 1*).

The application of nitrogen rates up to 100 kg/ha resulted in a significant increase in grain yield (averaged across all varieties). The application of 50 kg N/ha increased grain yield by 133% compared with the nil N application. The application of 100 kg N/ha increased grain yield by a further 17% above the 50 kg N/ha rate (*Figure 2*).

There was a significant grain yield response to increasing plant population, with the 40 kg/ha seeding rate (2.6 t/ha) yielding 0.40 t/ha more than the 20 kg/ha seeding rate (2.2 t/ha).

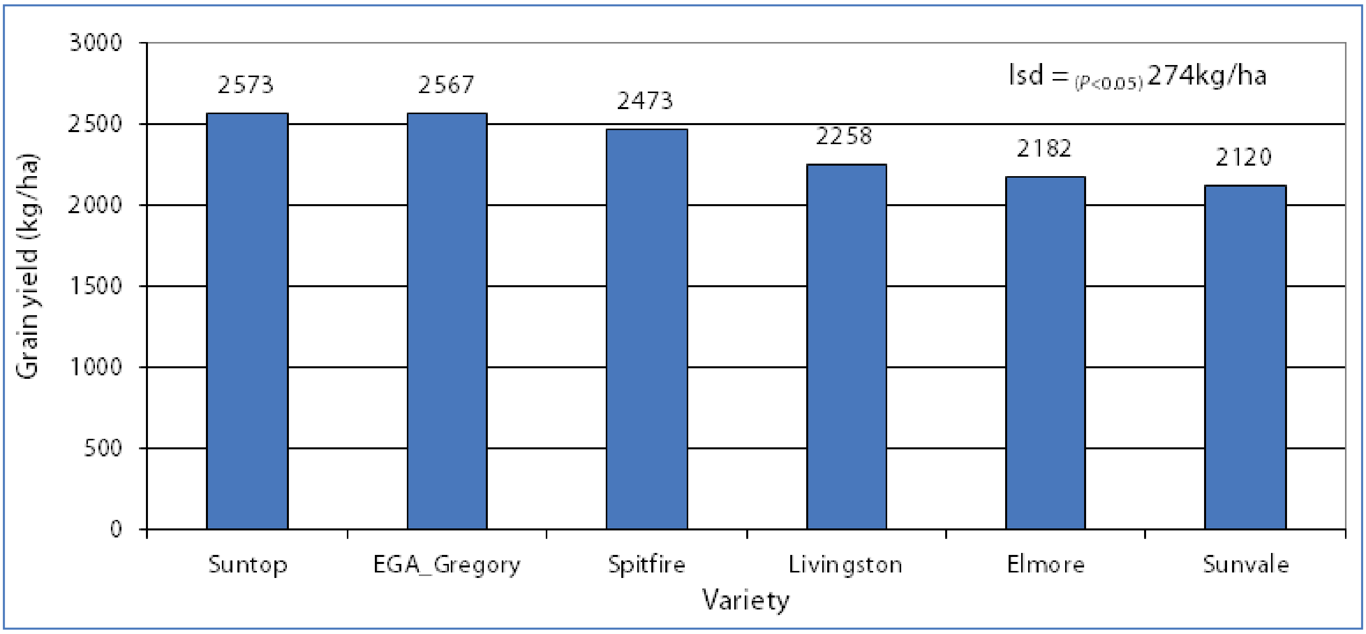

Figure 1: Grain yield of six wheat varieties averaged across four nitrogen rates and two seeding rates in an experiment at Merriwagga 2013.

The application of nitrogen at any rate did not increase grain protein concentration relative to the nil N treatment (*Table 1*). There was a significant reduction in grain protein concentration at the 50 kg N/ha rate relative to the nil N rate, however, this protein reduction was small compared with the yield increase.

Summary

Relative to the nil N treatment, the apparent efficiency of pre-drilled applied nitrogen was highest for the 50 kg N/ha rate (47%), reducing to 32% for the 100 kg N/ha rate, and 23% for the 150 kg N/ha rate. The return on investment for applied N was also highest at the lowest N rate of 50 kg N/ha, which is an important consideration in environments where responses to nitrogen fertiliser can be variable.

The application of nitrogen resulted in a significant grain yield increase but no increase in grain protein concentration. In certain seasons there may be potential to increase grain protein by delaying nitrogen application until in-crop, however, this could come at the expense of grain yield. There may also be few rainfall events that facilitate late season nitrogen applications in western environments.

Although there was no grain protein concentration increase at the 50 kg N/ha rate, the large increase in grain yield meant that the total amount of grain protein harvested on a hectare basis was significantly higher where N was applied.

Table 1: Effect of nitrogen rate on grain protein concentration of wheat averaged across six varieties and two seeding rates at Merriwagga 2013.

Nitrogen rate (kg/ha)	Grain protein concentration (%)
0	10.33
50	9.81
100	10.11
150	10.17
l.s.d. (P=0.05)	0.33

Acknowledgements

This experiment is part of the *Variety specific agronomy package* project (DAN00129, 2009–2012), jointly funded by GRDC and NSW DPI, conducted by AgGrow Agronomy.

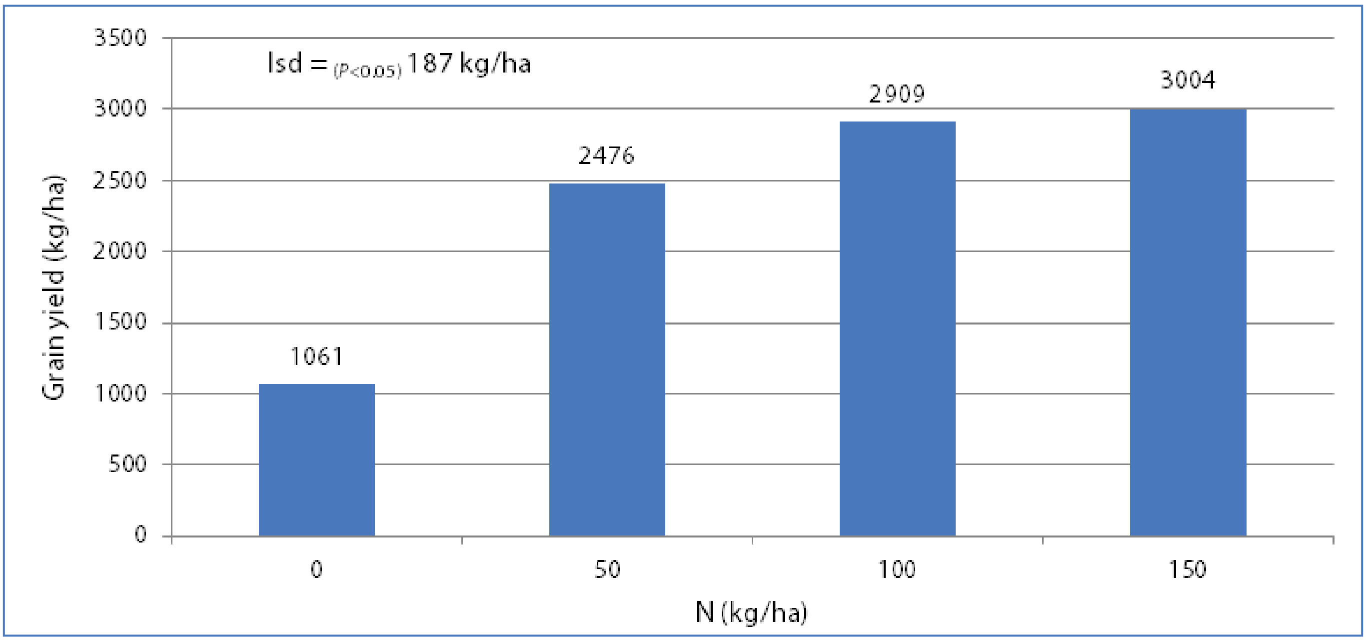

Figure 2: The effect of nitrogen rate on wheat yield averaged across six varieties and two seeding rates at Merriwagga 2013.

Response of wheat to nitrogen application and sowing time—Condobolin 2014

Ian Menz, Nick Moody and Daryl Reardon NSW DPI, Condobolin

Introduction

The experiment was conducted to determine the response of nine current wheat varieties sown at two dates to different rates and time of nitrogen application in the low rainfall zone. The experiment was established to measure grain yield and grain quality.

Site details

Location	Condobolin Agricultural Research and Advisory Station
Soil type	Red brown earth
Previous crop/s:	Wheat 2012 and 2013
Sowing dates	2 May and 21 May
Fertiliser	70 kg/ha MAP + Jubilee 400 mL/ha
Available N	68 kg/ha (0–60 cm)
In-crop rainfall	155 mm
Harvest date	21 and 27 November 2014

Treatments

Wheat varieties:	See *Table 2*
Nitrogen rates:	0, 20, 40, 80, 40 + 40 split* and 160 kg/ha

* Split application 40 kg/ha at sowing, 40 kg/ha @ GS 31

Season Conditions

In 2014 at Condobolin there were nine frost events in July with the coldest -3.8°C on 14 July. A further 13 frosts occurred in early August with the lowest recorded temperature of -5.4°C on 3 August. Between 2 August and 15 August, there were 10 mornings below -2.0°C.

The rainfall for the growing season was below average, with the Condobolin Agricultural Research and Advisory Station recording 155 mm April–October (*Table* 1). The bulk of this rain fell between April and June (113 mm). Long-term average (LTA) growing season rainfall is 209 mm.

Rainfall for the fallow period was 204.6 mm with 104.5 mm falling in March. LTA for the same period is 153 mm.

The experiment was sown into moisture and established quickly and evenly. The experiment was weed-free as a result of effective pre- and post-emergent herbicides. Low growing season rainfall (GSR) meant that the majority of crop growth was attributed to stored soil moisture.

Key findings

First time of sowing

- Yields were reduced by severe stem frost damage in July and August.
- Increasing nitrogen rates decreased grain yield at the first TOS.
- The highest yields were recorded in the zero nitrogen treatments.
- Sunguard was the highest yielding variety 1.07 t/ha.

Second time of sowing

- Emu Rock and Livingston yielded the highest, 1.19 t/ha and 1.11 t/ha, respectively.
- Averaged across all varieties and nitrogen rates, 20 kg/ha of applied nitrogen resulted in the highest yield.

Results

Variety and nitrogen rate interaction was highly significant ($p<0.001$). There was a significant difference ($p<0.05$) between the grain yields of the nine varieties (*Table 2*) and the response of grain yield to applied nitrogen (*Table 3*). At the first time of sowing, Sunguard

Table 2: Grain yield (t/ha) for nine wheat varieties sown 2 and 21 May at Condobolin, 2014. (Note LSD represents the differences within each TOS only)

Variety	Yield (t/ha)	
	TOS 1 - May 2	TOS 2 - May 27
Emu Rock	0.36	1.186
Livingston	0.80	1.106
Dart	0.49	0.995
Spitfire	0.62	0.965
Wallup	0.96	0.952
Sunguard	1.07	0.841
Suntop	0.70	0.818
EGA_Gregory	0.55	0.552
Lancer	0.92	0.516
l.s.d. (p<0.05)	0.12	0.150

Table 1: Monthly rainfall at the Condobolin Agricultural Research and Advisory Station, 2014.

Monthly Rainfall (mm)													Total	In-crop
Dec 2013	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec		
18.2	35.2	46.7	104.5	28	27.6	57.4	9.2	21.9	11	11.5	17.7	88.6	477.5	155.1

(1.07 t/ha), Wallup (0.96 t/ha) and Lancer (0.92 t/ha) were the highest yielding varieties. At the second sowing time Emu Rock (1.89 t/ha) was the highest yielding variety and Lancer (0.52 t/ha) was the lowest yielding.

There was a significant difference ($p<0.05$) between applied nitrogen rates averaged across all varieties. At the first time of sowing there was a decrease in grain yield as nitrogen rates increased. In the later time of sowing, grain yield decreased as nitrogen rates increased above 20 kg/ha (*Table 3*).

Table 3: Grain yield (t/ha) for six nitrogen application rates sown 2 and 21 May at Condobolin, 2014.

Nitrogen application (kg N/ha)	Yield (t/ha)	
	TOS 1 - May 2	TOS 2 - May 27
0	0.83	0.87
20	0.74	0.99
40	0.71	0.89
80	0.69	0.87
40+40 split	0.67	0.83
160	0.68	0.83
l.s.d. (p<0.05)	0.10	0.12

Grain Quality

The grain quality results were not available at the time of writing this report. Quality tests for grain protein, grain test weight and screenings will be conducted on the harvest samples.

Discussion

The experiment was sown on 2 May and 21 May 2014. The early sowing date had significant yield reduction from the frost events of July and August. The dry spring in 2014 also contributed to lower grain yields across both sowing dates. The ability of the plants to recover after the frosts was limited although some re-tillering occurred.

In the second sowing time the earlier maturity varieties such as Emu Rock and Dart yielded better than longer season spring wheats like Lancer. Whilst not an early maturing wheat, Livingston performed very well at the second sowing date (*Table 2*). The early maturing type varieties were more advanced during the dry spring conditions and, hence they filled slightly more grain with the limited available soil water before the season cut out. They were also late enough sown to avoid the severe frost damage of the first TOS.

The slow to medium maturing varieties, Lancer and EGA_Gregory yielded the lowest, 0.52 and 0.55 t/ha respectively in the second TOS. The lower yields of these longer season varieties could be attributed to the drier spring finish at Condobolin in 2014. Their yields in the first TOS were severely limited by the frost events that occurred in July and August.

It is likely that in the absence of the severe frost events that occurred during 2014 there would have been a significantly different outcome to this experiment; in particular the low yields of TOS1, therefore these results should be treated with caution.

Grain yield decreased as nitrogen rates increased in the first time of sowing. The increased biomass produced from high nitrogen application resulted in varieties "haying off". The second sowing date showed a significant response to 20 kg N/ha at sowing over the nil treatment.

Acknowledgements

This experiment is part of the *Variety specific agronomy package* project (DAN00167, 2013–2017), jointly funded by GRDC and NSW DPI.

Thanks to the operational and technical officers at Condobolin Agricultural Research and Advisory Station and Dr Neroli Graham for statistical analyses.

The effect of variety, plant population and nitrogen rate on high-yielding irrigated wheat production

Tony Napier NSW DPI, Yanco, Luke Gaynor, Deb Slinger, Cynthia Podmore NSW DPI, Wagga Wagga and Dr Neroli Graham NSW DPI, Tamworth

Key findings

- Variety selection and irrigation management are major drivers of high yielding irrigated wheat production.
- Suntop, Chara and Kiora were superior yielding varieties at both experiment sites.
- Plant density and nitrogen management can have a significant effect on grain yield.

Introduction

The importance of correct variety selection for dryland crops is well documented. Irrigated agriculture has the added pressure of uncertain water allocation and water cost which creates the need for irrigated crops to produce 'more crop per drop'. The first season's trials as part of the *Southern irrigated cereal and canola varieties achieving target yields* project showed the significant effect that management can have on irrigated grain yield.

Site details

Location	Leeton Field Station	Coleambally
Trial period	Winter crop growing season 2014	
Soil type	Self-mulching medium clay	Medium grey clay
Previous crop/s	Barley	Barley
Sowing date	7 May	14 May
Planter	Six rows per plot, row spacing 260 mm	Six rows per plot, row spacing 280 mm
Harvest date	9 December	10 December
Irrigation	1 autumn pre-irrigation plus 3 spring irrigations	1 autumn pre-irrigation plus 2 spring irrigations

Treatments

1. *Variety*

Bolac	Merinda	Impala
Suntop	Chara	Wallup
Corack	EGA_Gregory	Dart
Mace	Lancer	Kiora (VX2485)

2. *Nitrogen management*

Site	Treatment name	Nitrogen applied (kg N/ha)		
		Pre-sowing	1st node	Late post-emergent
Leeton Field Station	Pre-emergent	90	50	30
	Post-emergent	30	50	90
Coleambally	Pre-emergent	90	60	20
	Post-emergent	90	20	60

The Coleambally wheat experiment 2014.

3. *Plant population*

- Low – 140 established plants/m^2
- High – 210 established plants/m^2

Results

Suntop (10.32 t/ha) and Chara (10.32 t/ha) were the highest yielding varieties at Leeton followed by Kiora, Merinda and Corack. EGA_Gregory (8.84 t/ha) recorded the lowest yield and was statistically lower than all other varieties except Mace (9.05 t/ha) (*Figure 1*).

Suntop (7.33 t/ha) was the highest yielding variety at Coleambally followed by Lancer, Chara and Mace (*Figure 3*). Dart (5.86 t/ha) recorded the lowest yield and was statistically lower in yield than all other varieties. The Coleambally wheat experiment had one less spring irrigation than the Leeton experiment, which may explain the lower yields when compared to the Leeton experiment.

Nitrogen management

At Leeton, applying the majority of nitrogen (82%) post-emergent (at or after first node stage) yielded significantly higher (10.00 t/ha) than applying majority of the nitrogen (53%) pre-emergent (9.70 t/ha)

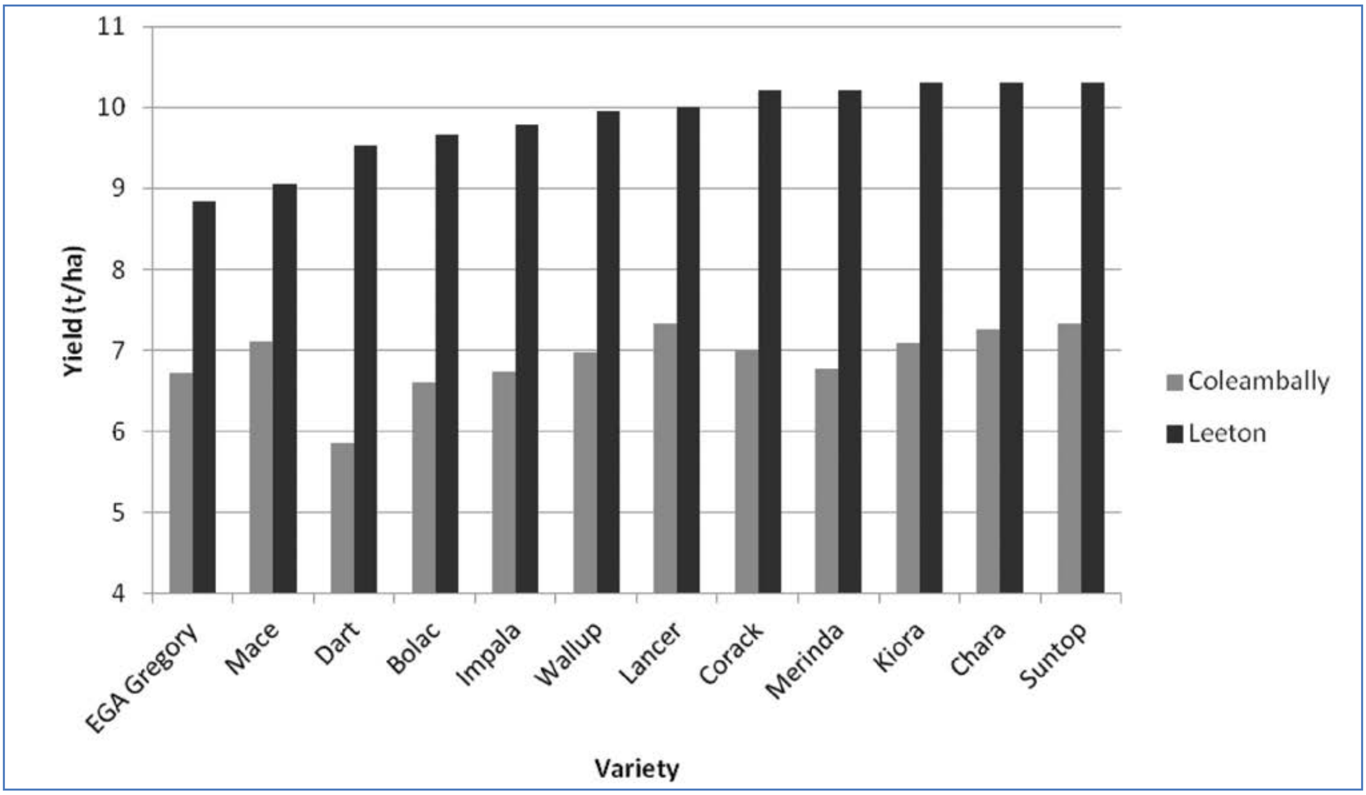

Figure 1: Wheat grain yield (t/ha) of each variety averaged across all nitrogen and plant population treatments at Leeton and Coleambally 2014.

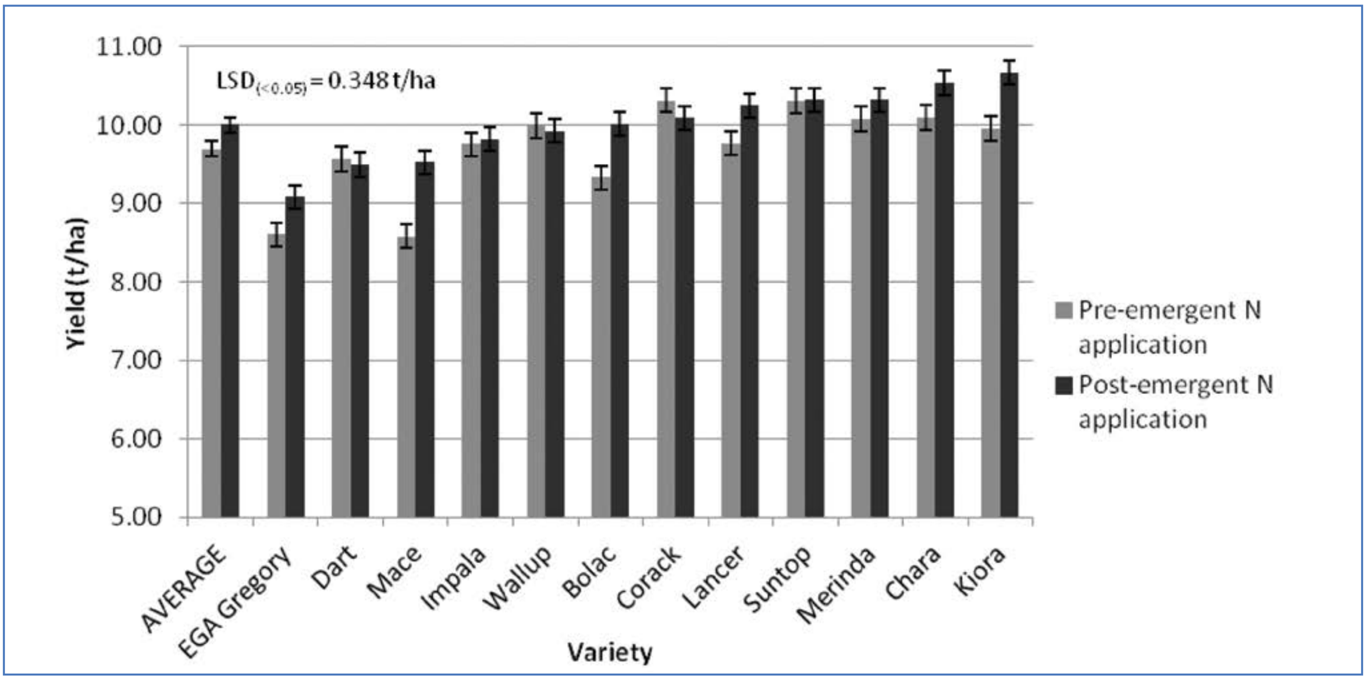

Figure 2: The effect of nitrogen application on grain yield for each variety and averaged across all varieties at Leeton 2014.

(*Figure 2*). At Coleambally, nitrogen management did not significantly affect grain yield.

At Leeton, in the post-emergent treatment Kiora (10.67 t/ha) was the highest yielding variety and EGA_Gregory (9.08 t/ha) was the lowest yielding variety (*Figure 2*). In the pre-emergent treatment, Corack (10.31 t/ha) was the highest yielding variety and Mace (8.58 t/ha) was the lowest yielding variety.

The interaction of variety and nitrogen management appears to be related to wheat maturity – the earlier maturing varieties performed better from earlier applications of nitrogen and the later maturing varieties performed better from the later applications of nitrogen.

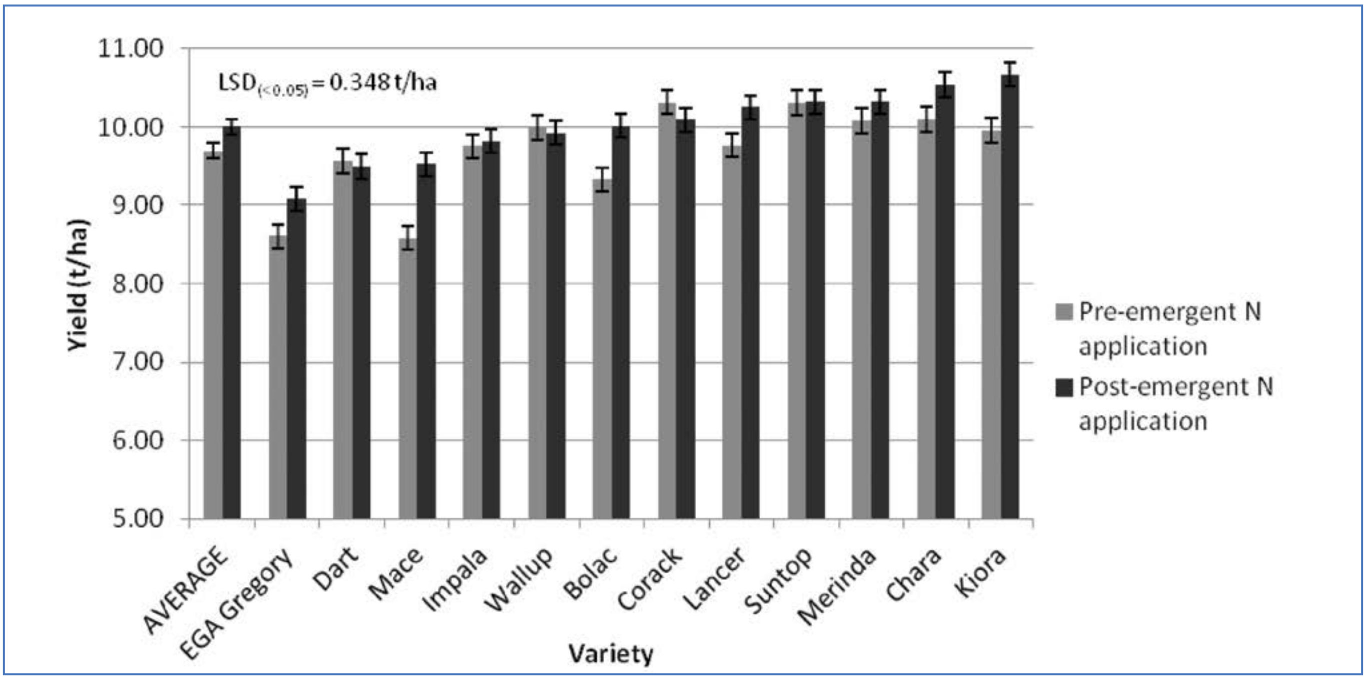

Figure 3. The effect of plant density on grain yield of each variety and averaged across all varieties at Leeton 2014.

Plant density

At Leeton, the low wheat plant density (140 plants/m2) resulted in a significantly higher average yield (9.90 t/ha) across all wheat varieties compared with the high plant density (210 plants/m2) (9.80 t/ha) (*Figure 3*). However, grain yield response to plant density differed between varieties which is likely due to the variety's ability to compensate with tillers.

At Leeton, in the low plant density treatments, Kiora (10.40 t/ha) was the highest yielding variety (*Figure 3*). Mace was the lowest yielding variety with a grain yield of 8.96 t/ha. In the high plant density treatment (210 plants/m^2), Chara (10.49 t/ha) was the highest yielding variety. EGA_Gregory was the lowest yielding variety with a grain yield of 8.53 t/ha. At Coleambally, plant density and the interaction of variety and plant density did not significantly affect grain yield.

Summary

These trials demonstrate that correct variety selection and agronomic management are key drivers of high yields but other management factors including nitrogen management and plant population will also impact grain yields. Suntop was the highest yielding variety at both sites while Chara was the second highest yielding at Leeton and third highest yielding at Coleambally. Applying the majority of nitrogen at or after first node resulted in higher yields compared to applying more nitrogen pre-sowing; however, there is a varietal effect. Lower plant density produced higher yields at Leeton (with a varietal effect) but there was no effect of plant population at Coleambally.

Acknowledgements

This research is part of the *irrigated cereal and canola varieties achieving target yields* project (DAN00198, 2014–2017) jointly funded by GRDC and NSW DPI.

The support of Glenn Morris, Paul Morris and Patrick Dando for assistance with management is gratefully acknowledged. We would also like to gratefully acknowledge David Bellato for allowing us to establish the Coleambally experiment on his property.

Response of wheat to sowing time—Condobolin 2014

Ian Menz, Nick Moody and Daryl Reardon NSW DPI, Condobolin

Key findings

- Grain yield of the 16 April sowing date was reduced by frost events during July and August.
- Lancer was the highest yielding variety (1.46 t/ha) averaged over all sowing times.
- Delaying sowing until TOS 3 (29 May) reduced wheat grain yield due to dry conditions during grain fill.
- Espada was the highest yielding variety (2.53 t/ha) for TOS 2 (7 May), but was low yielding in earlier (TOS 1) and later (TOS 3) sowing times.

Introduction

The experiment was established to determine the effect of sowing time on grain yield and quality of 32 new and current wheat varieties. Three sowing times were chosen to represent the span of the sowing window.

Site details

Location	Condobolin Agricultural Research and Advisory Station
Soil type	Red brown earth
Previous crop/s	Lucerne pasture (2012–2014), fallowed August 2014
Fertiliser	70 kg/ha MAP + Jubilee @ 400 mL/ha
Available N	175 kg/ha (0–60 cm)
In-crop rainfall	155 mm
Harvest date	12 November

Treatments

Sowing times	TOS 1: 16 April TOS 2: 7 May TOS 3: 29 May		
Varieties	Bolac	Condo	Corack
	Dart	EGA_Eaglehawk	Elmore
	Emu Rock	Espada	Forrest
	Gauntlet	EGA_Gregory	Impala
	Janz	Lancer	Lincoln
	Livingston	Viking	LPB09-0515
	LPB10-0018	Mace	Merinda
	Merlin	Phantom	Mitch
	Spitfire	Strzelecki	Sunmate
	Sunguard	Suntop	Sunzell
	Wallup	EGA_Wedgetail	

Seasonal conditions

There were an above average number of severe frost events during July and August, and below average spring rainfall in 2014.

Temperature data for this site showed that during July there were 9 frost events with the coldest on July 14 at -3.8°C. A total of 13 frosts occurred in early August with the lowest recorded temperature of -5.4°C on 3 August. Between 2 August and 15 August there were 10 days below -2.0°C. The first TOS showed signs of substantial frost damage which reduced yield.

The rainfall for the growing season was below average, with the Condobolin Agricultural Research and Advisory Station recording 155 mm April–October (*Table* 1). The bulk of this rain fell between April and June (113 mm). Long-term average (LTA) growing season rainfall is 209 mm.

Rainfall for the fallow period was 204.6 mm with 104.5 mm falling in March. LTA for the same period is 153 mm.

The experiment was sown into good moisture and established very quickly and evenly. The experiment was weed-free after good pre- and post-emergent herbicide efficacy and it was very uniform throughout the season.

Low in crop rainfall meant that the majority of crop growth was attributed to stored soil moisture. In-crop rainfall was 155 mm with LTA being 209 mm.

Results

Variety, TOS and Variety x TOS interaction were significant ($p<0.001$). There was a significant difference ($p<0.05$) between the TOS grain yield (*Figure 1*). The low yield in TOS 1 (16 April) was a result of frost events during July and August. The reduced yield in TOS 3 (29 May) could be attributed to a dry finish to the season with lower than average rainfall recorded in July, August and September (42 mm recorded, LTA 94 mm).

There was a significant difference ($p<0.05$) in grain yield for the 32 varieties across the three times of sowing (*Table 3*). The longer season varieties had lower

Table 1: Condobolin Agricultural Research and Advisory Station rainfall 2014.

Monthly Rainfall (mm)														
Dec 2013	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Total**	**In-crop**
18.2	35.2	46.7	104.5	28	27.6	57.4	9.2	21.9	11	11.5	17.7	88.6	477.5	155.1

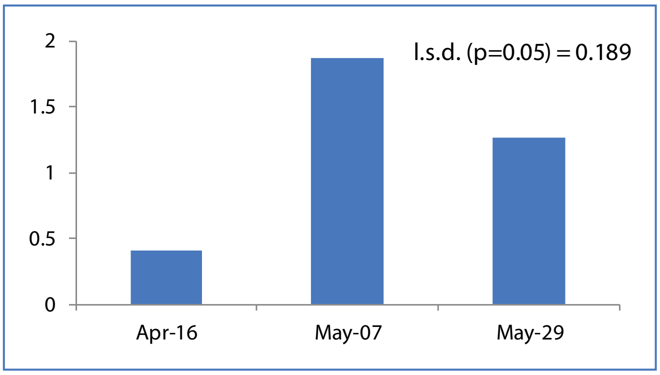

Figure 1: Average grain yield (t/ha) of 32 wheat varieties averaged across three times of sowing at Condobolin in 2014.

yield than the quick maturing varieties, due to the dry finish to the season.

There was a significant interaction ($p<0.05$) between variety and sowing time. All varieties, except EGA_Wedgetail, yielded highest from TOS 2 (*Table 3*). The long season variety EGA_Wedgetail was low yielding in all sowing times.

Grain quality

There was a significant interaction ($p<0.05$) in grain protein between variety and sowing time. Average protein levels were reduced by delaying sowing, with TOS 1 grain protein 15.5%, TOS 2 14.0% and TOS 3 13.4% (*Figure* 2).

There was a significant difference ($p<0.05$) in grain protein for the 32 varieties across the three time of sowing (*Table 4*).

Merlin had grain protein levels of 17.4, 15.1 and 14.3% for TOS 1, TOS 2 and TOS 3, respectively but the grain nitrogen yield (GNY) was lower for TOS 1 (2.6 kg N/ha) because of lower grain yield. For TOS 2 and 3 Merlin achieved higher GNY of 59 and 37 kg N/ha, respectively (*Table 4*).

Lancer was the highest yielding variety (1.46 t/ha) when averaged across all sowing times and achieved a GNY of 30, 55 and 29 kg N/ha from TOS 1, TOS 2 and TOS 3, respectively (*Table 4*).

Summary

In 2014 the experiment was affected by the number of severe frost events during July and August. These frost events contributed to the low yield shown in *Figure 1* and *Table 3* for TOS 1 (16 April). The early sowing time (TOS 1) was affected by stem frost early and the majority of the yield for this time of sowing was a result of re-tillering of the plants.

The drier than average spring conditions in the Condobolin region contributed to the lower than average yield of all varieties across the three sowing times.

Table 3: Grain yield (t/ha) for 32 wheat varieties at three sowing times at Condobolin, 2014.

Variety	Grain yield (t/ha)		
	TOS 1 - 16 Apr	TOS 2 - 7 May	TOS 3 - 29 May
Bolac	0.79	1.47	0.88
Condo	0.27	1.79	1.35
Corack	0.11	1.73	1.52
Dart	0.16	1.64	1.58
EGA_Eaglehawk	0.48	0.78	0.67
Elmore	0.59	2.34	1.35
Emu Rock	0.19	1.52	1.69
Espada	0.24	2.53	1.40
Forrest	0.99	1.29	0.68
Gauntlet	0.80	1.99	1.12
EGA_Gregory	0.69	1.83	1.06
Impala	0.33	2.13	1.29
Janz	0.72	2.20	1.08
Lancer	1.15	2.13	1.11
Lincoln	0.11	1.97	1.42
Livingston	0.08	2.11	1.48
Viking	0.24	1.78	1.27
LPB09-0515	0.27	2.53	1.45
LPB10-0018	0.14	2.25	1.68
Mace	0.10	1.87	1.62
Merinda	0.29	2.28	1.44
Merlin	0.09	2.24	1.49
Phantom	0.21	1.72	1.19
Mitch	0.51	1.81	1.19
Spitfire	0.01	2.11	1.64
Strzelecki	1.14	1.95	0.96
Sunmate	0.15	2.15	1.57
Sunguard	0.79	2.08	1.06
Suntop	0.45	2.23	1.69
Sunzell	0.69	1.18	0.95
Wallup	0.14	2.08	1.19
EGA_Wedgetail	0.21	0.23	0.56
l.s.d.(p<0.05)	0.37		

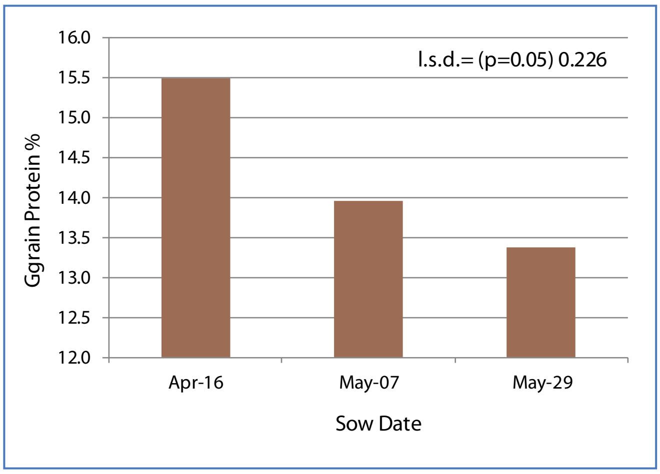

Figure 2: Average grain protein level (%) of 32 wheat varieties across the three times of sowing, Condobolin 2014.

Table 4: Grain protein levels (%) and grain nitrogen yield (kg N/ha) of 32 wheat varieties across three times of sowing.

	Grain protein (%)			Grain nitrogen yield (kg N/ha)		
Variety	**TOS1 - Apr 16**	**TOS 2 - May 07**	**TOS 3 - May 29**	**TOS 1 - Apr 16**	**TOS 2 - May 07**	**TOS 3 - May 29**
Bolac	15.3	15.0	14.7	21.2	38.5	22.8
Condo	15.7	13.0	12.0	7.5	40.7	28.4
Corack	15.5	13.5	11.7	2.9	40.8	31.2
Dart	16.9	14.0	12.8	4.8	40.3	35.2
EGA_Eaglehawk	16.1	15.5	14.5	13.6	21.2	17.1
Elmore	14.5	13.2	13.0	14.8	53.8	30.5
Emu Rock	16.4	14.6	12.4	5.5	38.9	36.7
Espada	15.6	13.4	12.7	6.7	59.5	31.0
Forrest	15.4	15.4	15.4	26.7	34.8	18.3
Gauntlet	14.9	13.9	13.9	20.7	48.5	27.3
EGA_Gregory	14.5	13.6	12.9	17.4	43.5	24.0
Impala	15.2	13.2	12.8	8.6	49.4	28.9
Janz	14.7	13.2	13.3	18.5	50.9	25.0
Lancer	15.1	14.7	14.7	30.4	54.8	28.5
Lincoln	16.0	13.5	13.3	3.0	46.5	33.0
Livingston	15.9	13.2	12.8	2.1	48.7	33.1
LPB09-0515	15.2	13.2	13.7	7.1	58.3	33.8
LPB10-0018	15.3	13.0	12.7	3.7	51.3	37.4
Mace	16.4	13.0	12.0	2.9	42.3	34.1
Merinda	15.8	13.0	12.9	7.9	51.7	32.6
Merlin	17.4	15.1	14.3	2.6	59.0	37.2
Mitch	14.0	12.9	12.7	12.6	41.0	26.3
Phantom	15.8	15.1	14.0	5.8	45.3	29.0
Spitfire	15.7	15.0	14.2	0.3	55.4	40.8
Strezleki	14.7	14.4	13.8	29.3	49.1	23.1
Sunguard	14.2	13.5	12.8	19.7	49.0	23.9
Sunmate	15.5	12.5	12.1	4.0	46.9	33.2
Suntop	15.2	13.4	12.9	12.0	52.5	38.3
Sunzell	15.5	15.0	13.9	18.7	31.0	23.0
Viking	14.8	14.0	13.5	6.3	43.6	30.1
Wallup	15.9	13.9	13.8	3.8	50.5	28.9
EGA_Wedgetail	16.4	16.6	15.7	6.0	6.8	15.4
l.s.d. (p<0.05)	0.518					

Lancer had high grain yield when comparing all varieties across all sowing times. The sowing times of 16 April and 7 May are within the recommended sowing window for Lancer in the Condobolin region. Espada was the highest yielding named variety in TOS 2 (7 May), and highest for the whole experiment (*Table 3*).

The longer season varieties such as EGA_Wedgetail and EGA_Eaglehawk achieved the lowest average yield at 0.33 and 0.65 t/ha, respectively, when compared across the three sowing times (*Figure* 2).

Many of these varieties may have performed differently if the seasonal conditions had not had such a large influence on the 16 April and 29 May sowing. As a result of the seasonal conditions at Condobolin in 2014, most varieties in this experiment set were best suited to the 7 May sowing.

Acknowledgements

This experiment is part of the *Variety specific agronomy package* project (DAN00167, 2013–2017), jointly funded by GRDC and NSW DPI.

Thanks to the operational and technical officers at Condobolin Agricultural Research and Advisory Station, and Dr Neroli Graham for statistical analyses.

Response of wheat to sowing time and plant population—Condobolin 2014

Ian Menz, Nick Moody and Daryl Reardon NSW DPI, Condobolin

Key findings

- Suntop at 100 plants/m² (7 May) was the highest yielding variety (2.14 t/ha) across all sowing times.
- Seeding rates that established 100 plants/m² achieved the highest yield at a 7 May sowing.
- Dart at 200 plants/m² was the highest yielding variety (1.69 t/ha) from the 16 April sowing.
- Grain yield of 16 April sowing was reduced because of severe frosts which occurred during July and August.
- The dry finish during the grain filling period reduced the grain yields of the 29 May sowing.

Introduction

The experiment was conducted to determine the response of new and current wheat varieties to a range of sowing times and plant populations in the low rainfall region. The experiment was established to measure grain yield and quality of 8 varieties spanning the sowing window of central west NSW (*Table 1*).

Site details

Location	Condobolin Agricultural Research and Advisory Station
Soil type	Red brown earth
Previous crop/s	Lucerne pasture (2012–2014), fallowed August 2014
Fertiliser	70 kg/ha MAP + Jubilee @ 400 mL/ha
Available N	175 kg/ha (0–60 cm)
In-crop rainfall	155 mm
Harvest date	13 November

Treatments

Table 1: Varieties, seeding rates and sowing times for wheat time of sowing (TOS) by seed rate (SR) at Condobolin, 2014.

8 wheat varieties	Dart, EGA_Eaglehawk, EGA_Gregory, Lancer, Spitfire, Sunguard, Suntop, Wallup
3 seeding rates (SR)	50, 100 and 200 plants/m²
3 sowing times (TOS)	TOS 1 – 16 April TOS 2 – 7 May TOS 3 – 29 May

Seasonal conditions

There were an above average number of severe frost events during July and August, and below average spring rainfall in 2014.

Temperature data for this site showed that during July there were 9 frost events with the coldest on July 14 at -3.8°C. A total of 13 frosts occurred in early August with the lowest recorded temperature of -5.4°C on 3 August. Between 2 August and 15 August there were 10 days below -2.0°C. The first TOS showed signs of substantial frost damage which reduced yield.

The rainfall for the growing season was below average, with the Condobolin Agricultural Research and Advisory Station recording 155 mm April–October (*Table 2*). The bulk of this rain fell between April and June (113 mm). Long-term average (LTA) growing season rainfall is 209 mm.

Rainfall for the fallow period was 204.6 mm with 104.5 mm falling in March. LTA for the same period is 153 mm.

The experiment was sown into moisture and established very quickly and evenly. The experiment was weed-free as a result of effective pre- and post-emergent herbicides. The experiment was very uniform throughout the season.

Low in crop rainfall meant that the majority of crop growth was attributed to stored soil moisture. In-crop rainfall was 155 mm with LTA being 209 mm.

Results

TOS, variety x sowing rate and TOS x variety x sowing rate interactions were significant ($p<0.001$). There were significant differences ($p<0.05$) between the TOS grain yields (*Figure 1*). The low yield in TOS 1 (16 April) was a result of frost events during July and August with the coldest record on 3 August at -5.4. The lower yield of TOS 3 (29 May) could be attributed to a dry finish to the season with lower than average rainfall in July, August and September (42 mm recorded, LTA 93.9 mm).

There was an increase in grain yield of 1.31 t/ha from the 16 April sowing time to the 7 May sowing time, and a decrease between 7 May sowing (0.71 t/ha) and 29 May sowing (*Figure 1*). The low yield in the 16 April

Table 2: Monthly rainfall at the Condobolin Agricultural Research and Advisory Station, 2014.

Monthly Rainfall (mm)														
Dec 2013	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total	In-crop
18.2	35.2	46.7	104.5	28	27.6	57.4	9.2	21.9	11	11.5	17.7	88.6	477.5	155.1

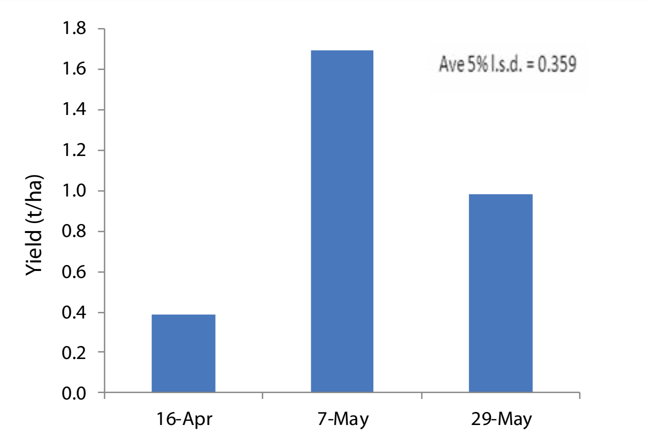

Figure 1: Average grain yield (t/ha) of eight wheat varieties across three sowing times at Condobolin, 2014.

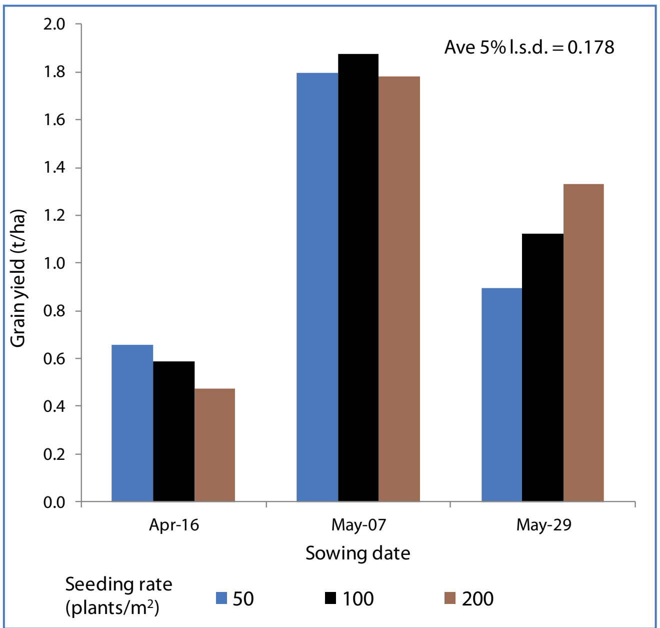

Figure 2: Average grain yield of plant population 50, 100 and 200 plants per square metre across three sowing times at Condobolin, 2014.

sowing could be attributed to the severe frost events of July and August.

There was a significant difference ($p<0.05$) between time of sowing, variety and seeding rate (*Table 3*). All varieties achieved the highest yields from the 7 May sowing time across all seeding rates , apart for Dart at 200 plants/m^2 which yielded 1.62 t/ha (7 May) and 1.69 t/ha (29 May).

Dart, Spitfire and Wallup yields were extremely low in the 16 April sowing across all plant populations. This could be attributed to the plants being more advanced during the period of severe frost events and the plants could not compensate for the loss of tillers.

There was a significant difference ($p<0.05$) between the time of sowing and the plant population (*Figure 2*). A yield increase occurred for all three plant populations between the 16 April and 29 May

Table 3: Grain yield (t/ha) of eight wheat varieties sown at three seeding rates, each at three sowing times at Condobolin, 2014.

Variety-sowing rate (kg/ha)	Yield (t/ha)		
	TOS 1 - 16 Apr	TOS 2 - 7 May	TOS 3 - 29 May
Dart-100	0.01	1.66	1.25
Dart-200	0.01	1.62	1.69
Dart-50	0.03	1.48	0.91
EGA_Eaglehawk-100	0.29	0.77	0.19
EGA_Eaglehawk-200	0.14	0.63	0.48
EGA_Eaglehawk-50	0.62	0.96	0.35
EGA_Gregory-100	0.64	1.54	0.46
EGA_Gregory-200	0.44	1.60	0.94
EGA_Gregory-50	0.72	1.90	0.52
Lancer-100	0.90	1.97	0.87
Lancer-200	0.87	1.81	1.09
Lancer-50	1.03	1.66	1.00
Spitfire-100	0.01	1.93	1.64
Spitfire-200	0.01	1.83	1.59
Spitfire-50	0.01	1.68	0.94
Sunguard-100	1.13	2.02	0.73
Sunguard-200	0.85	1.90	1.23
Sunguard-50	0.93	1.88	0.42
Suntop-100	0.31	2.14	1.47
Suntop-200	0.27	1.68	1.46
Suntop-50	0.51	2.03	1.13
Wallup-100	0.01	2.06	1.08
Wallup-200	0.01	1.95	1.26
Wallup-50	0.13	1.90	0.82
l.s.d. ($p<0.05$)	0.372		

sowing time. The 200 plants/m^2 yielded 0.43 t/ha at a 16 April sowing, whereas in the 29 May sowing the same plant population achieved 1.33 t/ha. The 50 and 100 plants/m^2 plant populations also had a yield increase from the 16 April to the 29 May sowing (*Figure 2*).

There was a significant difference ($p<0.05$) between the plant population with Suntop at 100 plants/m^2 (7 May) being the highest yielding variety (2.14 t/ha) across all sowing times. Dart at 200 plants/m^2 was the highest yielding variety (1.69 t/ha) from the 16 April sowing (*Table 3*). Similar yields were achieved across all plant populations in the 7 May sowing; 50 plants/m^2 yielded 1.80 t/ha, 100 plants /m^2 yielded 1.88 t/ha and the 200 plants/m^2 yielded 1.78 t/ha.

This lower yield for the 16 April sowing could be attributed to the stem and head frost events. The lower yields in the 29 May sowing compared to the 7 May sowing were a result of the dry finish with below average rainfall in July, August and September (*Table 2*).

The grain quality results were not available at the time of writing this report. Quality tests for grain protein, grain test weight and screenings will be done on the harvest samples.

Summary

Although there were small varietal and density effects, the main determinant of yield in 2014 was the seasonal conditions. At TOS 1 all varieties and densities were badly affected by severe frosts and had low yields. TOS 2 (7 May) was optimal for yield in 2014 and all densities achieved similar yields. Only at TOS 3 (29 May) was there a significant density interaction with higher yields from increasing plant density. This is consistent with previous research which has shown that increasing plant density will in part compensate for the inability of individual plants to tiller and establish sufficient biomass to set up yield potential.

Acknowledgements

This experiment is part of the *Variety specific agronomy package* project (DAN00167, 2013–2017), jointly funded by GRDC and NSW DPI.

Thanks to the operational and technical officers at Condobolin Agricultural Research and Advisory Station and Dr Neroli Graham for statistical analyses.

Effect of sowing date on grain yield of wheat—Deniliquin 2014

Eric Koetz NSW DPI, Wagga Wagga, John Fowler Local Land Services, Deniliquin and Karl Moore NSW DPI, Wagga Wagga

Key findings

- Water-logging after late irrigation restricted TOS 3 grain yields.
- Long season varieties EGA_Wedgetail and Kiora had the highest yields in the first sowing date.
- Delaying sowing to mid-May increased grain yield averaged across all varieties.
- Viking was the highest yielding variety at the second and third sowing date.

Introduction

This experiment was designed to assess the effect of early and late sowing dates on the phenology and grain yield of several newer wheat varieties in comparison with traditionally grown varieties in the Murray Valley of southern NSW. Wheat varieties respond differently to sowing time. There are different responses in flowering time and relative grain yield with changes in time of sowing. This experiment is one in a series of time of sowing experiments aimed at establishing variety responses to sowing time. The influence of supplementary irrigation on grain yield across sowing times was also investigated.

Site details

Location	Deniliquin, NSW
Trial period	2014
Soil type	Grey vertisol
Previous crop/s	Canola
Stubble management	Direct drill, standing stubble
Planter	Plot air seeder, DBS tynes
Harvest date	19 November 2014
Fertiliser	100 kg/ha DAP
Soil tests	pH_{Ca} 5.4
Nitrogen	160 kg N/ha tested 1.5 m
Phosphorous	55 mg/kg
Herbicides	Knockdown: RoundupCT 1.5 L/ha Pre-emergent: Logran 35 g/ha + Sakura 118 g/ha Post Emergent: Prosaro 150 mL/ha + Hasten 1% v/v Lontrel 300 g 150 mL/ha + 600 mL/ha MCPA LVE

Treatments

Twenty seven wheat varieties and crossbreds that are likely to be released (*Table 1*) sown at three dates in three replicates: 30 April, 20 May, 18 July.

Results

Grain yield

Variety and sowing date had significant effects on grain yield (P<0.001). The interaction between variety and sowing date was also significant (p<0.001) (*Table 1*). Delaying sowing from 30 April until 20 May increased yield by an average of .050 t/ha (*Table 2*).

Table 1: Average grain yield of wheat varieties sown at three dates at Deniliquin in 2014.

Variety	Grain yield (t/ha)		
	TOS 1 - 30 Apr	TOS 2 - 20 May	TOS 3 - 18 Jul
Bolac	4.73	4.75	2.02
Cobra	4.43	4.68	1.90
Condo	3.83	4.17	3.20
Corack	3.39	4.75	2.06
Dart	3.19	3.61	1.61
EGA_Gregory	4.46	4.83	1.92
EGA_Wedgetail	5.34	5.02	2.25
Elmore	4.47	4.62	2.61
Emu Rock	3.45	3.97	1.75
Gauntlet	4.12	4.57	2.44
Impala	4.10	4.03	1.82
Kiora	4.78	5.15	1.75
Lancer	4.68	4.72	2.29
Livingston	3.22	4.06	2.72
LPB09-0515	3.61	4.80	2.19
LPB10-0018	3.51	4.21	2.70
Mace	3.99	4.20	2.41
Merlin	3.37	4.14	1.92
Phantom	4.41	5.11	2.48
Scout	4.71	5.02	2.42
Spitfire	3.90	3.77	2.70
Sunguard	3.71	4.36	1.67
Sunmate	4.66	4.79	2.98
Suntop	4.61	4.95	2.66
Trojan	3.46	4.62	3.18
Viking	4.16	5.52	3.23
Wallup	2.94	3.77	1.74
lsd	833		

The decrease in grain yield from TOS 3 was a result of water-logging from the last irrigation. Grain yield increased as sowing time was delayed (*Table 2*).

Grain Protein

The mean grain protein concentration was 14.1%. There was a significant difference (p=0.05) between genotype, sowing time and a significant interaction between sowing time and genotype. The average grain protein concentration was highest at the last sowing time. Grain protein of long season varieties such as EGA_Wedgetail and Kiora increased as sowing was delayed, whereas for Suntop and Sunmate grain protein concentrations decreased. Spitfire averaged across all three sowing dates had the highest grain protein concentration and Kiora had the lowest (*Table 3*).

There was a significant difference (p<0.05) in grain nitrogen yield between genotype, sowing time and an interaction between genotype and sowing time (*Figure 1*). There was a dramatic reduction in nitrogen removal from the third sowing date as corresponding crop yields were very low.

Summary

Grain yield increased from the first to second sowing date. Given the application of a late irrigation the third sowing date was expected to yield equal to or above the previous dates. Waterlogging from irrigation and following heavy rain reduced grain yield significantly (p=0.05). Waterlogging was recorded for a 16 day period after the irrigation of the last time of sowing. There was some minor damage to plots from frost events especially the first time of sowing; however, most of the damage was limited to the outside rows. The long season winter wheat EGA_Wedgetail was the highest yielding variety from the first sowing date. Long season spring wheats such as Kiora also performed well at the first two sowing dates. Viking was the highest yielding variety at the second and third sowing date. Grain protein concentrations were highest in Spitfire and Merlin.

Acknowledgements

This experiment is part of the *Variety specific agronomy package* project (DAN00167, 2013–2017), jointly funded by GRDC and NSW DPI.

The technical assistance of Greg McMahon, Warren Bartlett, Russell Pumpa and Sharni Hands is greatly appreciated.

Table 2: Grain yield of each time of sowing averaged across twenty seven wheat varieties at Deniliquin in 2014.

Sowing date	Grain yield (t/ha)
TOS 1 - 30 April	4.04
TOS 2 - 20 May	4.50
TOS 3 - 18 July	2.30
lsd	0.28

Table 3: Average grain protein concentration of twenty seven wheat varieties sown at three dates at Deniliquin in 2014.

Variety	Grain protein (%)	Variety	Grain protein (%)
Bolac	13.3	LPB09-0515	13.3
Cobra	14.0	LPB10-0018	14.4
Condo	14.5	Mace	13.7
Corack	13.9	Merlin	16.5
Dart	14.6	Phantom	13.8
EGA_Gregory	13.0	Scout	14.4
EGA_Wedgetail	13.4	Spitfire	16.7
Elmore	13.3	Sunguard	14.2
Emu Rock	15.0	Sunmate	13.9
Gauntlet	13.9	Suntop	13.8
Impala	13.5	Trojan	13.9
Kiora	12.5	Viking	12.6
Lancer	14.5	Wallup	15.3
Livingston	15.6		

lsd=0.9

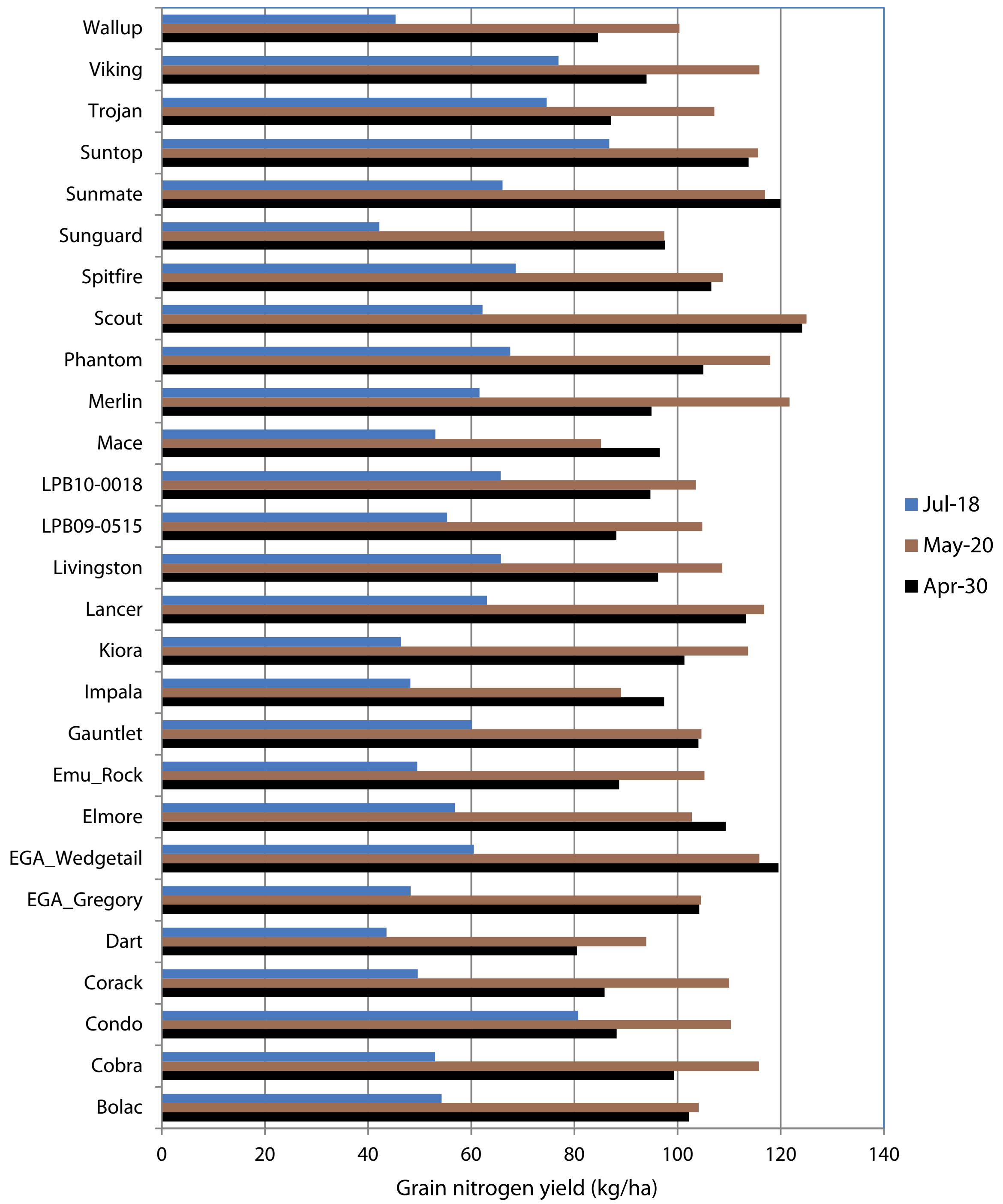

Figure 1: Average grain nitrogen yield of twenty seven wheat varieties sown at three dates at Deniliquin in 2014.

Effect of sowing date on grain yield of twenty three wheat and seven barley varieties—Lockhart 2014

Eric Koetz, Rohan Brill and Karl Moore NSW DPI, Wagga Wagga

Introduction

This experiment was designed to assess the effect of early and late sowing dates on the phenology and grain yield of several newer wheat and barley varieties in comparison with commonly grown varieties in southern NSW. Wheat and barley varieties respond differently to sowing time. There are different responses in flowering time and relative grain yield with changes in time of sowing. This experiment is one in a series of time of sowing experiments aimed at determining variety responses to sowing time.

Site details

Location	Lockhart, NSW
Trial period	2014
Soil type	Grey vertisol
Previous crop/s	Barley
Stubble management	Direct drill, standing stubble
Planter	Plot air seeder, 250 mm DBS tynes
Harvest date	19 November 2014
Fertiliser	100 kg/ha DAP
Soil pH_{Ca}	6.6
Nitrogen	180 kg/ha to 1.2 m depth
Phosphorous	35 mg/kg
Herbicides	Knockdown: RoundupCT 1.5L/ha Pre-emergent: Logran 35g/ha + Boxer Gold 2.5l/ha Post Emergent: Precept 500 mL/ha + Lontrel 150 mL/ha
Fungicide	Flutriafol @ 400ml/ha on fertiliser at sowing

Treatments

Varieties	Twenty three wheat and seven barley varieties (including pre-released lines) (*Table 2*).
Sowing dates	TOS 1 – 29 April 2014
	TOS 2 – 19 May

Key findings

- Flowering occurred approximately three weeks earlier than normal because of the warmer temperatures in autumn and winter.
- Early flowering varieties in the first sowing date were badly affected by severe stem frosts.
- Barley varieties tolerated early frost events better than wheat in TOS 1.
- Six of the seven barley varieties were among the 12 top yielding lines in TOS 1.
- Hindmarsh, Fathom and Commander were the highest yielding varieties in TOS 2.
- In TOS 2, Hindmarsh out-yielded the best wheat (Corack) by 0.7 t/ha.

Results

Grain yield

Variety and sowing date had highly significant effects on grain yield ($P<0.001$). The interaction between variety and sowing date (*Table 2*) was also significant ($p<0.001$). Delaying sowing from 29 April until 19 May increased yield by an average of 1.02 t/ha (*Table 1*).

The severe frost events in late July and early August killed the main stems of the early maturing varieties. Barley varieties were less affected by the frost events in TOS 1 and were the top yielding lines in TOS 2 (*Table 2*).

Grain protein

Variety ($P<0.001$) and sowing date ($P<0.05$) and the interaction between variety and seeding date were significant for grain protein concentration and grain nitrogen yield (*Table 3*). There was a strong correlation with total nitrogen removal and grain yield (*Table3*).

Grain nitrogen yield (kg/ha) was calculated using the formula:

Grain nitrogen yield = yield * (grain protein concentration*1.75)

Grain quality information on screenings and test weight were not available at the time of publication.

Table 2: Average grain yield of twenty three wheat and seven barley varieties sown at two dates at Lockhart in 2014.

Sowing date	Grain yield (t/ha)
TOS 1 - 29 April	1.12
TOS 2 - 19 May	2.17
lsd	0.245

Table 1: Average grain yield and rank of twenty three wheat and seven barley varieties sown at two dates at Lockhart in 2014.

TOS 1 – 29 April			TOS 2 – 19 May		
Variety	**Yield (t/ha)**	**Rank**	**Variety**	**Yield (t/ha)**	**Rank**
Sunvale	1.71	1	Hindmarsh	3.58	1
Fathom[B]	1.70	2	Fathom	3.44	2
Elmore	1.68	3	Commander	3.25	3
Compass[B]	1.65	4	Compass	3.20	4
Sunguard	1.58	5	Corack	2.86	5
Lancer	1.55	6	La_Trobe	2.85	6
Hindmarsh[B]	1.54	7	Buloke	2.63	7
Commander[B]	1.42	8	Mace	2.53	8
Gauntlet	1.36	9	GrangeR	2.41	9
GrangeR[B]	1.33	10	Elmore	2.38	10
LPB09-0515	1.28	11	Emu Rock	2.32	11
La_Trobe[B]	1.23	12	Spitfire	2.24	12
Condo	1.19	13	Condo	2.10	13
Viking	0.97	14	Sunguard	2.02	14
Kiora	0.97	15	Sunmate	1.97	15
Impala	0.97	16	LPB10-0018	1.86	16
EGA_Wedgetail	0.96	17	Lancer	1.81	17
Livingston	0.95	18	Kiora	1.80	18
Suntop	0.93	19	Impala	1.79	19
Mace	0.93	20	Sunvale	1.77	20
Corack	0.91	21	Bolac	1.75	21
Bolac	0.91	22	Dart	1.73	22
Buloke[B]	0.89	23	Livingston	1.73	23
EGA_Gregory	0.89	24	Suntop	1.69	24
Sunmate	0.88	25	LPB09-0515	1.68	25
EGA_Eaglehawk	0.85	26	Viking	1.66	26
LPB10-0018	0.72	27	Gauntlet	1.62	27
Emu Rock	0.66	28	EGA_Gregory	1.62	28
Dart	0.61	29	EGA_Eaglehawk	1.46	29
Spitfire	0.58	30	EGA_Wedgetail	1.27	30
lsd	0.58				

[B] barley

Table 3: Grain protein concentration and grain nitrogen yield of twenty three wheat and seven barley varieties sown at two dates at Lockhart in 2014.

	Grain protein (%)			Grain nitrogen (kg/ha)		
Variety	**TOS 1 – 29 April**	**TOS 2 – 19 May**	**mean**	**TOS 1 – 29 April**	**TOS 2 – 19 May**	**mean**
Bolac	15.1	15.1	15.1	23	46	34
Buloke[B]	15.8	14.7	15.2	25	69	47
Commander[B]	14.5	14.0	14.2	36	79	57
Compass[B]	14.7	13.5	14.1	42	76	59
Condo	15.7	14.7	15.2	34	54	44
Corack	15.3	14.5	14.9	22	74	48
Dart	16.0	15.3	15.6	16	49	32
EGA_Eaglehawk	14.6	14.5	14.6	21	41	31
EGA_Gregory	14.1	14.1	14.1	21	42	32
EGA_Wedgetail	14.6	15.1	14.9	24	36	30
Elmore	14.9	16.2	15.6	44	67	56
Emu Rock	15.8	14.8	15.3	18	60	39
Fathom[B]	14.9	13.6	14.3	45	82	64
Gauntlet	14.4	14.9	14.7	33	41	37
GrangeR[B]	15.4	15.6	15.5	34	77	56
Hindmarsh[B]	15.0	13.3	14.1	41	85	63
Impala	14.0	14.4	14.2	25	43	34
Kiora	15.5	15.4	15.4	27	49	38
La_Trobe[B]	16.4	13.5	14.9	36	64	50
Lancer	14.3	15.5	14.9	38	50	44
Livingston	14.8	14.6	14.7	23	47	35
LPB09-0515	14.4	15.8	15.1	32	46	39
LPB10-0018	14.4	14.2	14.3	17	47	32
Mace	15.5	14.4	14.9	25	64	44
Spitfire	16.7	15.4	16.1	17	59	38
Sunguard	14.3	15.2	14.7	39	52	46
Sunmate	14.2	15.1	14.6	21	53	37
Suntop	15.2	15.1	15.2	24	44	34
Sunvale	14.3	15.5	14.9	42	51	46
Viking	14.8	15.4	15.1	25	43	34
lsd	0.72					

[B] Barley

Discussion

The combination of the warm autumn and early winter temperatures accelerated crop development exposing the crop to the stem frost events in July and August. Fast maturing varieties sown early elongated and flowered outside their preferred window, exposing them to severe frosts which significantly reduced grain yield. The grain yield recorded from TOS 1 was recovered from secondary tiller regrowth after the frosts. The plants had the capacity to regenerate after the death of the main tillers producing enough secondary regrowth to recover some grain yield. The lack of spring rainfall was also a contributing factor to reduced yields from the first sowing date. Barley varieties performed strongly in this experiment, especially at TOS 2.

Grain nitrogen yield was higher in the second TOS, a response to the increased grain yields. Grain protein concentration was higher in the first TOS and is likely a reflection of a combination of the frost damage and the dry spring which contributed to low grain yields.

Averaged across both sowing dates barley varieties had higher grain nitrogen yield than wheat.

Acknowledgements

This experiment is part of the *Variety specific agronomy package* project (DAN00167, 2013–2017), jointly funded by GRDC and NSW DPI.

The assistance of Greg McMahon, Russell Pumpa, Sharni Hands and Warren Bartlett is appreciated. We thank John Stephenson from “Warakirri” for hosting the experiment.

Effect of sowing date on grain yield of wheat—Wagga Wagga 2014

Eric Koetz and Karl Moore NSW DPI, Wagga Wagga

Introduction

This experiment was designed to assess the effect of early, mid and late sowing dates on the phenology and grain yield of several newer wheat varieties in comparison with traditionally grown varieties in southern NSW. Wheat varieties respond differently to sowing time. There are different responses in flowering time and relative grain yield with changes in time of sowing. This experiment is one in a series of time of sowing experiments aimed at establishing variety responses to sowing time.

Key findings

- Flowering occurred approximately three weeks earlier than normal because of the warm autumn and winter.
- Early flowering varieties in the first sowing date were badly affected by severe stem frosts.
- Long season varieties had stable yields at all three sowing times.
- Corack, Mace and Trojan had the highest grain yields in the second and third sowing dates.
- Later flowering correlated with higher yield.

Site details

Location	Wagga Wagga, NSW
Trial period	2014
Soil type	Red brown earth
Previous crop/s	Canola
Stubble management	Direct drill, stubble harrowed
Planter	Plot air seeder, DBS tynes
Harvest date	19 November 2014
Fertiliser	100 kg/ha DAP
Soil pH_{Ca}	4.4
Nitrogen	46 kg N/ha tested 1.2 m
Phosphorous	43 mg/kg
Herbicides	Knockdown: RoundupCT 1.5 L/ha Pre-emergent: Logran 35 g/ha + Sakura 118g/ha Post Emergent: Precept 500 mL/ha + Lontrel 150ml/ha Axial 150 mL/ha
Fungicide	Flutriafol 400 mL/ha on fertiliser at sowing
In-crop rainfall	278 mm

Treatments

Thirty six varieties and crossbreds likely to be released (*Table 2*) sown at three dates: 14 April, 5 May, and 26 May.

Table 1: Average grain yield of thirty six wheat varieties sown at three dates at Wagga in 2014

Sowing date	Grain yield (t/ha)
TOS 1 - 14 April	1.62
TOS 2 - 5 May	2.42
TOS 3 - 26 May	2.61
l.s.d.	0.14

Results

Flowering

Variety, sowing date and the interaction between variety and sowing date had a significant effect on flowering date ($p<0.001$) (*Figure 1*). The warmer than average temperatures in autumn and winter resulted in the number of days from sowing on 14 April to flowering being 14 days less than the long-term average.

Varieties sown on April 14 were flowering in early to late August and were exposed to severe stem frost events during the vulnerable stem elongation and boot stages.

Grain Yield

Variety and sowing date had significant effects on grain yield ($P<0.001$). The interaction between variety and sowing date was also significant ($p<0.001$). Delaying sowing from 14 April until 5 May increased yield by an average of 0.80 t/ha (*Table 1*).

Grain yield increased as sowing time was delayed (*Table 2*). The latest sowing time (May 26) was 0.10 t/ha higher yielding than the earliest sowing time (April 14) (*Table 1*).

Grain protein

Grain Nitrogen yield (kg/ha) was calculated using the formula:

Grain nitrogen yield = Yield * (grain protein concentration*1.75)

Variety ($P<0.001$) and sowing date ($P<0.05$) and the interaction between variety and seeding date were significant for grain protein concentration and grain nitrogen yield (*Table 3*).

Table 2: Grain yield and anthesis date of thirty six wheat varieties sown at three dates at Wagga in 2014.

Variety	Grain yield (t/ha)			Flowering date		
	TOS 1 - 14 Apr	TOS 2 - 5 May	TOS 3 - 26 May	TOS 1 - 14 Apr	TOS 2 - 5 May	TOS 3 - 26 May
ADV03-0056	1.39	2.81	2.72	9 Sep	25 Sep	6 Oct
Bolac	2.33	2.17	2.05	17 Sep	1 Oct	11 Oct
Chara	1.99	2.50	2.53	17 Sep	30 Sep	8 Oct
Condo	1.59	2.50	2.89	31 Aug	20 Sep	30 Sep
Corack	0.81	2.85	3.37	31 Aug	23 Sep	2 Oct
Dart	1.34	2.06	2.63	11 Aug	21 Sep	29 Sep
EGA_Eaglehawk	1.79	2.33	2.12	5 Oct	8 Oct	12 Oct
EGA_Gregory	1.62	2.63	2.49	18 Sep	30 Sep	8 Oct
EGA_Wedgetail	2.26	2.21	2.32	1 Oct	8 Oct	12 Oct
Elmore	1.66	2.44	2.75	9 Sep	28 Sep	7 Oct
Emu Rock	1.45	2.48	3.06	16 Aug	25 Sep	2 Oct
Forrest	1.83	2.12	2.12	29 Sep	5 Oct	12 Oct
Gauntlet	1.48	2.57	2.93	12 Sep	26 Sep	7 Oct
Impala	1.80	1.94	2.37	9 Sep	23 Sep	3 Oct
Janz	1.48	2.35	2.82	11 Sep	26 Sep	7 Oct
Kiora	2.44	2.58	2.40	18 Sep	30 Sep	9 Oct
Lancer	2.25	2.84	2.58	17 Sep	30 Sep	12 Oct
Livingston	0.63	2.28	2.76	8 Sep	23 Sep	-
LPB09-0515	1.58	2.55	2.74	7 Sep	25 Sep	6 Oct
LPB10-0018	1.66	2.52	2.79	3 Sep	22 Sep	2 Oct
Mace	1.08	3.11	3.22	11 Sep	24 Sep	2 Oct
Merinda	0.96	1.99	2.47	10 Sep	26 Sep	4 Oct
Merlin	0.99	2.41	2.24	30 Aug	27 Sep	5 Oct
Mitch	2.22	1.85	2.29	17 Sep	30 Sep	7 Oct
Naparoo	2.51	2.35	2.34	7 Oct	13 Oct	16 Oct
Phantom	1.50	2.71	2.63	13 Sep	28 Sep	6 Oct
Scout	2.15	2.74	2.72	8 Sep	27 Sep	6 Oct
Spitfire	0.56	2.07	2.57	29 Aug	24 Sep	3 Oct
Sunguard	1.87	2.55	2.65	18 Sep	28 Sep	7 Oct
Sunmate	1.08	2.18	2.60	3 Sep	23 Sep	4 Oct
Suntime	1.84	1.94	2.31	26 Sep	4 Oct	8 Oct
Suntop	1.99	2.51	2.51	16 Sep	27 Sep	7 Oct
Sunvale	1.89	2.28	2.38	17 Sep	29 Sep	8 Oct
Trojan	1.79	2.90	3.01	9 Sep	27 Sep	5 Oct
Viking	1.43	2.25	2.69	12 Sep	29 Sep	7 Oct
Wallup	1.18	2.53	2.73	5 Sep	24 Sep	6 Oct
lsd p>(0.05) 0.431 t/ha						

Table 3: Grain protein concentration and grain nitrogen yield of thirty six wheat varieties sown at three dates at Wagga in 2014.

Variety	Grain protein (%)				Grain nitrogen yield (kg N/ha)			
	Sowing date				Sowing date			
	TOS 1 - 14 Apr	TOS 2 - 5 May	TOS 3 - 26 May	Mean	TOS 1 - 14 Apr	TOS 2 - 5 May	TOS 3 - 26 May	Mean
ADV03-0056	15.6	13.0	13.7	14.1	37.6	64.3	65.3	34.0
Bolac	15.9	15.7	17.8	16.5	63.5	58.6	63.0	37.8
Chara	15.8	14.8	16.7	15.8	54.3	64.6	73.8	38.5
Condo	16.7	14.7	15.0	15.5	46.3	65.3	76.3	37.5
Corack	17.3	14.5	14.3	15.4	25.2	72.4	84.9	36.6
Dart	17.2	14.9	14.9	15.7	41.6	52.7	68.9	34.1
EGA_Eaglehawk	15.8	15.7	16.2	15.9	49.6	62.6	60.1	35.7
EGA_Gregory	15.3	14.3	15.4	15.0	42.3	66.3	66.9	35.7
EGA_Wedgetail	16.4	16.6	17.6	16.9	65.5	65.0	70.9	40.3
Elmore	16.1	15.1	16.0	15.7	45.9	64.4	76.7	37.7
Emu Rock	16.8	15.6	14.6	15.7	42.4	68.7	77.5	37.7
Forrest	15.1	16.0	16.5	15.9	40.8	60.5	61.2	34.4
Gauntlet	16.4	13.7	14.7	14.9	42.0	62.2	75.6	36.1
Impala	15.5	13.7	14.1	14.4	48.6	47.5	58.9	32.4
Janz	15.6	14.1	15.4	15.0	33.8	57.8	75.3	34.5
Kiora	15.2	15.6	16.9	15.9	65.1	68.8	71.5	40.5
Lancer	16.6	15.3	17.6	16.5	65.3	75.7	79.1	42.7
Livingston	17.2	14.9	14.5	15.5	17.9	59.3	70.5	31.8
LPB09-0515	16.2	13.9	15.1	15.1	44.8	53.4	71.9	34.8
LPB10-0018	16.0	14.1	14.6	14.9	34.1	60.2	71.6	34.2
Mace	17.2	13.7	14.3	15.1	23.5	74.2	80.1	35.8
Merinda	16.8	13.8	14.2	14.9	28.9	45.5	61.2	29.7
Merlin	18.5	15.6	16.7	16.9	21.1	65.5	65.9	33.1
Mitch	14.3	14.0	14.6	14.3	54.1	36.2	59.2	31.7
Naparoo	15.8	17.0	18.0	16.9	68.8	68.9	72.9	41.7
Phantom	15.8	13.7	15.3	14.9	42.2	65.2	70.9	36.0
Scout	16.2	14.6	15.7	15.5	60.0	70.7	74.5	40.1
Spitfire	18.7	15.8	16.6	17.0	17.6	58.6	74.0	32.8
Sunguard	15.9	14.4	15.2	15.2	52.7	64.9	70.0	37.4
Sunmate	15.9	13.5	14.6	14.7	28.4	50.7	65.6	31.0
Suntime	14.8	14.9	15.5	15.1	47.8	50.2	63.2	33.8
Suntop	15.3	13.8	14.6	14.6	52.6	61.3	64.8	35.9
Sunvale	15.4	15.0	17.0	15.8	49.4	59.2	71.2	36.8
Trojan	15.0	14.1	15.7	14.9	48.5	73.2	83.1	39.9
Viking	15.4	14.6	16.0	15.3	41.0	57.5	75.6	35.7
Wallup	16.9	14.7	15.8	15.8	34.9	66.2	75.5	36.1
lsd= p>(0.05) 0.566								

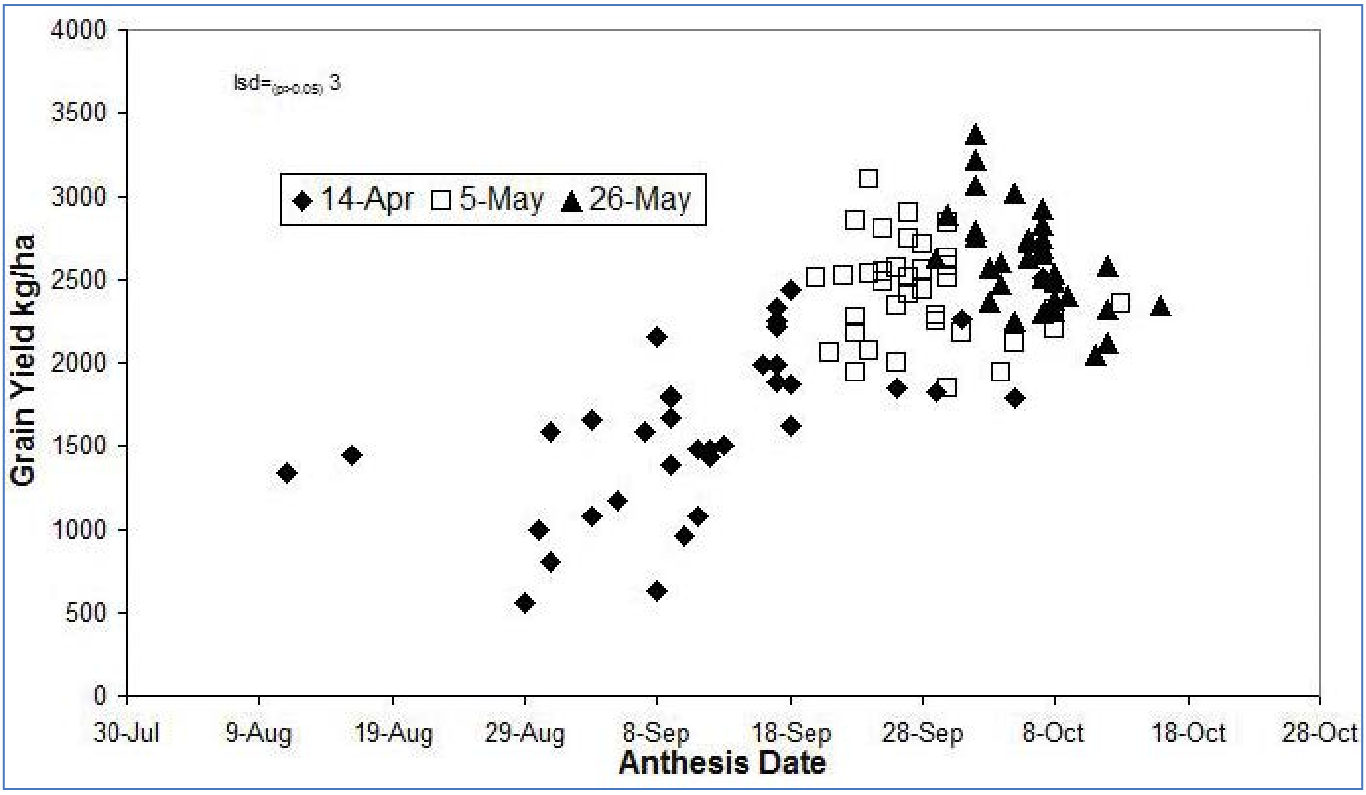

Figure1: Effect of anthesis date on grain yield of 36 wheat varieties sown at three sowing dates at Wagga in 2014.

Summary

The winter types and long season varieties (EGA_Wedgetail and Kiora) maintained yield across all three sowing dates despite the early frost events. Main season varieties such as Spitfire, Corack and Livingston sown on 14 April had reduced grain yield as a result of the August frosts. In contrast to recent seasons, delaying sowing in 2014 resulted in increased grain yield averaged across all varieties. Corack, Trojan and Mace were the highest yielding varieties in time of sowing two and three. This was likely the result of these later sowing dates escaping the damage of the early stem frost events in July and August. Targeting the optimal flowering window reduced the impact of the stem frost events allowing varieties to fill grain.

The high average grain protein of 15.5% is likely a reflection of high starting N and topdressing in a dry season with a particularly dry spring.

Acknowledgements

This experiment is part of the *Variety specific agronomy package* project (DAN00167, 2013–2017), jointly funded by GRDC and NSW DPI.

The technical assistance of Greg McMahon, Russell Pumpa, Sharni Hands and Warren Bartlett is appreciated.

Effect of sowing date on grain yield and grain protein of wheat—Canowindra 2014

Colin McMaster, Rob Dunkley NSW DPI, Cowra and Eric Koetz NSW DPI, Wagga Wagga

Key findings

- Mace sown on 7 May was the highest yielding variety (6.1 t/ha).
- Incorrect matching of variety maturity and sowing time caused a grain yield reduction of up to 4.9 t/ha.
- Grain yield was maximised by sowing slow to mid-fast spring wheats in the first week of May.
- Long season wheats sown in mid-April produced below average grain yield, but were relatively stable across all 3 times of sowing. Yields were affected by BYDV.
- High yield losses occurred by sowing quick maturing varieties early, rather than longer season varieties late in 2014.

Introduction

Recent research and crop modelling data (Hunt *et al*, 2013), has identified potential grain yield advantages in sowing slow maturing wheat varieties with either strong vernalisation (winter wheats) or photoperiod requirements if seasonal conditions allow an early sowing opportunity in early to mid-April.

The aim of this experiment was to investigate how recently released wheat varieties respond to various times of sowing. Wheat varieties included long season winter wheats to very fast spring wheats (*Table 2*).

Site details

Location	"The Pines" Canowindra NSW
Soil type	Clay loam
Previous crop/s	Canola (2013)
Stubble management	Stubble incorporated
Harvest date	21 November
Fertiliser	20 kg P/ha + 50 kg N/ha at GS32
Soil pH_{Ca}	6.4
Fungicide	Flutriafol treated fertiliser (400 mL/ha) Prosaro (200 mL/ha) applied @ GS39
In-crop rainfall	192mm

Treatments

Time of sowing (3)	TOS1 = 17 April TOS2 = 7 May TOS3 = 28 May		
Wheat varieties (30)	Bolac Corack Condo Dart EGA_Eaglehawk EGA_Gregory Elmore Emu Rock Forrest Gauntlet	HRZ03-0056 Impala Kiora Lancer Livingston LPB09-0515 LPB10-0018 Mace Merinda Mitch	Naparoo Spitfire Suntime Sunguard Sunmate Suntop Sunvale Viking Wallup EGA_Wedgetail

Results

The 2014 season was characterised with good autumn rainfall that provided ideal sowing conditions to germinate and establish all wheat varieties across three sowing dates. The combination of warm temperatures and adequate soil moisture resulted in rapid growth and development, on average 11 days ahead by July according to Hunt *et al* 2015.

The 2014 winter will be remembered for being cold and frosty with a total of 31 frost events from 19 June to 3 October.

Grain yield

Wheat grain yield was significantly affected by time of sowing ($P<0.001$), variety ($P<0.001$) and the interaction between sowing time and variety ($P<0.001$). The interaction between variety maturity type and time of sowing was also significant ($P<0.001$).

When averaged over all 30 varieties, grain yield was significantly higher when sown on 7 May (5.19 t/ha) compared to either 17 April (2.75 t/ha) or 28 May (4.01 t/ha) (*Table 3*).

Table 1: Wheat maturity groups and suggested sowing window for central eastern NSW. Groups marked * are spring wheat types

Maturity	Suggested sowing window	Variety
Winter	Late Feb to late April	Maparoo, EGA_Wedgetail
Very slow*	early to mid/late April	Bolac, EGA_Eaglehawk, Forrest
Slow*	mid April to early May	Lancer, Suntime, Kiora
Mid*	late April to mid May	EGA_Gregory, Gauntlet, Viking, Sunvale, Mitch
Mid–fast*	early May to mid May	Elmore, Impala, Sunguard, Suntop, Wallup, Merinda, HRZ03-0056
Fast*	mid May onwards	Corack, Emu Rock, Livingston, Mace, Spitfire, Sunmate, LPB10-0018
Very fast*	late May to June	Dart, Condo

The highest yielding variety was Mace (6.12 t/ha) sown on 7 May (*Table 3*).

Varieties that performed well across all sowing dates (above average yields in each TOS) include EGA_Gregory, Elmore, LPB09-0515 and Suntop. These varieties ranged from mid to mid-fast maturity (*Table 2*).

Very slow to slow maturing varieties such as Kiora, Bolac, Forrest, Lancer and Suntime performed well on early sowing, but poorly with later sowing (*Table 3*).

Fast to very fast maturing varieties performed poorly on early sowing but well with later sowing, and include Condo, LPB10-0018, Mace, Corack and Dart.

Quicker maturing varieties sown in mid-April suffered major yield penalties due to flowering during extreme frost events. For example Corack had a 4.91 t/ha grain yield reduction if sowing was brought forward 20 days from 7 May to 17 April (*Table1*).

On average, long season varieties (winter wheats and very slow spring wheats) sown 17 April produced disappointing grain yields, and suffered a 2.06 t/ha grain yield reduction compared to slow maturing spring wheat varieties sown on 7 May (*Figure 1*). Despite the low grain yields on the long season varieties, they were relatively stable across the three sowing dates.

Table 3: Grain yield and rank of 30 wheat varieties sown at three sowing dates at Canowindra 2014.

Variety	Grade (south)	Maturity	Grain yield (t/ha) and Rank					
			TOS 1 - 17 Apr		TOS 2 - 7 May		TOS 3 - 28 May	
Bolac	APH	Very slow*	4.40	2	5.16	20	3.80	24
Condo	AH	Very fast*	1.97	21	5.46	10	4.78	1
Corack	APW	Fast maturing*	0.77	28	5.69	4	4.70	3
Dart	AH	Very fast*	1.21	25	4.66	26	4.48	5
EGA_Eaglehawk	APH	Very slow*	3.61	8	4.65	27	3.60	27
EGA_Gregory	AH	Mid maturing*	3.33	14	5.44	11	4.37	9
Elmore	AH	Mid-fast maturing*	3.20	16	5.41	12	4.33	11
Emu Rock	AH	Fast maturing*	1.21	26	4.79	25	4.24	13
Forrest	ASW	Very slow*	4.37	3	5.28	16	3.57	28
Gauntlet	AH	Mid maturing*	3.20	15	5.70	3	4.04	19
HRZ03-0056		Mid-fast maturing*	2.34	20	5.48	9	4.09	16
Impala	Soft	Mid-fast maturing*	2.76	18	5.26	17	4.43	6
Kiora	AH	Slow maturing*	4.48	1	5.51	7	3.93	22
Lancer	APH	Slow maturing*	4.25	4	5.56	5	4.02	20
Livingston	AH	Fast maturing*	0.56	29	4.85	23	4.30	12
LPB09-0515		Mid-fast maturing*	3.49	11	5.36	13	4.40	7
LPB10-0018		Fast maturing*	1.75	22	5.24	18	4.78	2
Mace	AH	Fast maturing*	1.74	23	6.12	1	4.40	8
Merinda	AH	Mid-fast maturing*	2.49	19	5.05	21	4.18	14
Mitch	APW	Mid maturing*	3.54	10	4.80	24	3.83	23
Naparoo	Feed	Winter wheat	3.13	17	3.73	30	3.20	29
Spitfire	APH	Fast maturing*	0.46	30	4.64	28	3.74	26
Suntime		Slow maturing*	3.92	5	5.04	22	4.06	18
Sunguard	AH	Mid-fast maturing*	3.66	7	5.29	14	4.01	21
Sunmate	AH	Fast maturing*	1.03	27	5.22	19	4.50	4
Suntop	APH	Mid-fast maturing*	3.45	13	5.54	6	4.36	10
Sunvale	APH	Mid maturing*	3.79	6	5.29	15	3.76	25
Viking	APH	Mid maturing*	3.47	12	5.50	8	4.06	17
Wallup	APH	Mid-fast maturing*	1.27	24	5.75	2	4.14	15
EGA_Wedgetail	APH	Winter wheat	3.57	9	4.20	29	3.04	30
		Min	0.46		3.73		3.04	
		Mean	2.75		5.19		4.10	
		Max	4.48		6.12		4.78	

L.S.D (P0.05) TOS = 221 Variety = 193 Variety x TOS = 367

* Spring wheat

Grain protein and grain nitrogen yield

Grain protein and grain nitrogen yield was significantly affected by time of sowing (P<0.001), variety (P<0.001) and the interaction between sowing time and variety (P<0.001). Refer to *Table 4* for results.

Figure 2 shows that total nitrogen removal was highly correlated with grain yield.

Summary

These results highlight that specialist varieties exist for specific sowing dates, which enable grain yield to be maximised for a given sowing window. However, a specialist variety sown outside of its window may result in large yield penalties, as seen in this experiment.

Given the high frequency of frost events in 2014, larger yield penalties were experienced when quick maturing varieties was sown early, compared to long season varieties sown late.

Some varieties were well suited to a given sowing time whilst other varieties were solid performers over a much broader sowing window. Whilst these varieties did not achieve maximum yield at any given sowing date, they should be given strong consideration if there is limited opportunity to store several seed options for 2015 sowing.

Long season wheats sown in mid-April produced disappointing results. This may be explained by the high aphid infestations that were present at the 2-3 leaf stage, as visual symptoms were present for BYDV. Despite the poor performance of the winter wheats, grain yield was relatively stable across all three sowing times.

Growers and advisers are encouraged not to make variety decisions based on one data set alone, and should also refer to: *Yield response of wheat varieties to sowing time 2011* (Dr Peter Martin, Chris Lisle, Frank McRae and Peter Matthews; NVT website; or the *Winter crop variety sowing guide* published annually by NSW DPI.

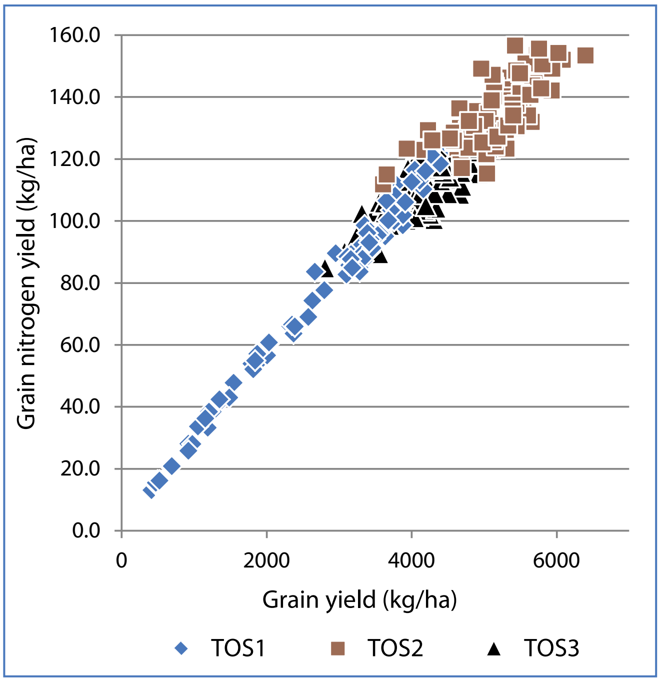

Figure 2: Relationship between grain yield and grain nitrogen yield across three sowing dates at Canowindra 2014.

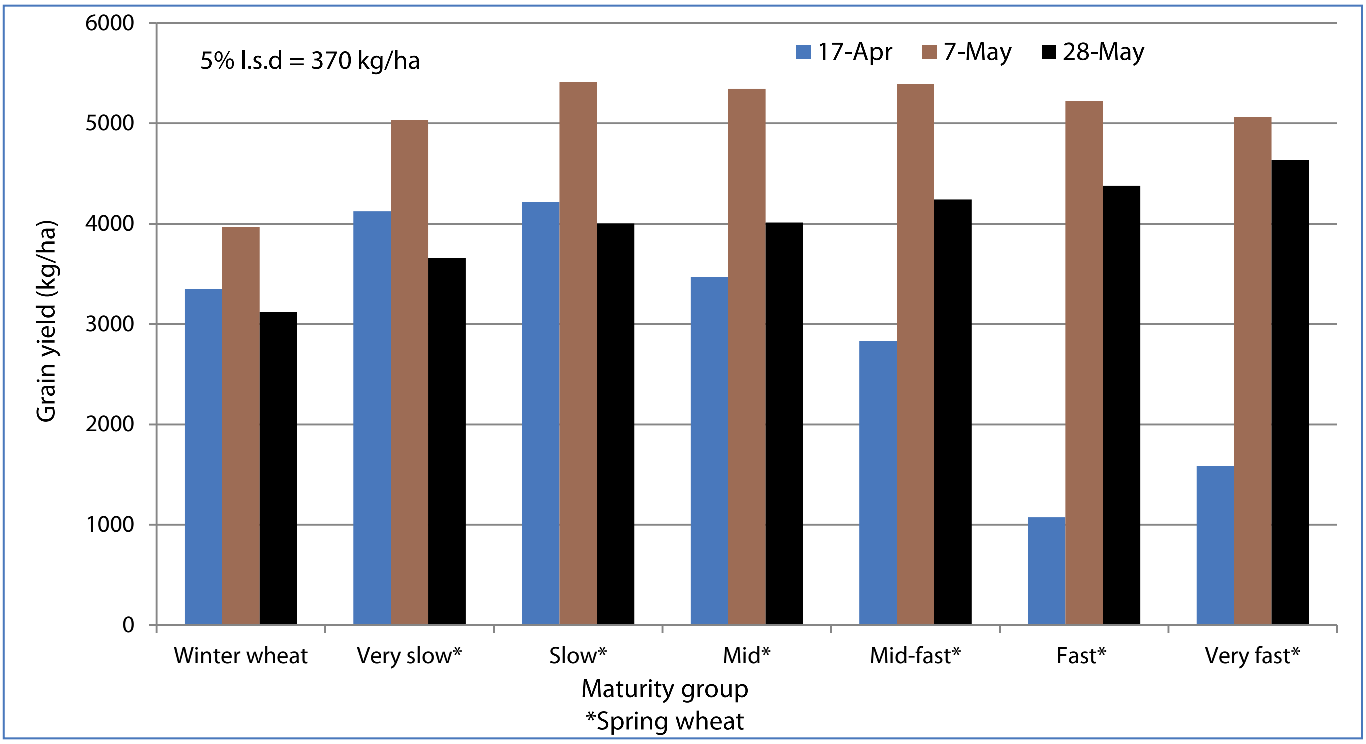

Figure 1: Average grain yield of various maturity groups across three sowing dates at Canowindra 2014.

Table 4: Grain protein and grain nitrogen yield of 30 wheat varieties sown at 3 sowing times at Canowindra 2014.

Variety	Grain protein (%)			Grain nitrogen yield (kg N/ha)		
	TOS 1 - 17 Apr	TOS 2 - 7 May	TOS 3 - 28 May	TOS 1 - 17 Apr	TOS 2 - 7 May	TOS 3 - 28 May
Bolac	16.2	16.7	16.8	124.4	151.1	111.6
Condo	17.0	13.9	14.3	58.6	132.7	119.5
Corack	17.3	14.1	13.6	23.4	140.7	112.1
Dart	17.9	15.4	14.5	37.9	125.3	114.2
EGA_Eaglehawk	16.1	16.0	15.5	99.8	130.2	95.6
EGA_Gregory	15.1	14.4	14.9	88.0	136.9	114.2
Elmore	16.0	15.1	15.4	89.4	142.8	116.7
Emu Rock	18.1	15.6	15.1	38.3	130.3	111.9
Forrest	15.6	15.9	16.7	119.5	147.1	104.3
Gauntlet	15.3	14.4	15.6	85.6	143.7	109.7
HRZ03-0056	16.0	13.8	14.3	65.6	131.8	102.6
Impala	15.2	13.9	14.4	73.2	127.7	111.2
Kiora	15.6	15.5	15.8	121.9	149.7	108.6
Lancer	16.1	15.4	16.5	119.5	149.7	116.5
Livingston	17.7	15.0	14.9	17.2	127.0	111.9
LPB09-0515	15.6	14.4	15.1	94.7	134.9	116.1
LPB10-0018	16.4	14.1	14.3	50.3	128.9	119.7
Mace	17.4	14.2	14.2	52.9	152.3	109.0
Merinda	16.1	14.3	15.1	70.0	126.3	110.3
Naparoo	17.4	17.9	17.3	95.0	116.7	96.7
Mitch	14.8	14.2	14.6	91.6	118.9	97.7
Spitfire	18.5	16.1	16.8	14.9	130.6	109.7
Sunguard	15.4	15.1	15.4	98.7	139.4	108.2
Sunmate	16.1	13.4	13.6	29.0	122.6	106.8
Suntime	15.4	15.2	15.1	105.5	133.5	106.8
Suntop	15.5	14.2	14.2	93.2	137.7	108.2
Sunvale	15.8	15.5	16.8	105.0	143.3	110.4
Viking	15.0	13.9	15.0	90.9	133.7	106.7
Wallup	17.6	14.5	15.4	38.9	145.7	111.6
EGA_Wedgetail	16.7	17.2	16.9	104.4	126.1	89.9
Min	15	13	14	15	117	90
Mean	16	15	15	77	135	109
Max	19	18	17	124	152	120
L.S.D (P0.05)						
TOS	0.17			7.44		
Variety	0.25			4.85		
Variety x TOS	0.44			10.03		

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Hunt, J., Rheinheimer, B., Swan, T., Goward, L., Fettell, N., Haskins, B., Whitworth, R., Ryan, M. and Pratt, T. (2015) Early sowing in 2014 – how did it go? *GRDC Advisor Update Wagga Wagga* proceedings.

Acknowledgements

This experiment is part of the *Variety specific agronomy package* project (DAN00167, 2013–2017), co-funded by GRDC and NSW DPI.

Support from Peter Watt (Elders, Cowra) and Peter Wilson (Lachlan Fertiliser, Cowra) is gratefully acknowledged in assisting with harvesting this experiment.

Thank you to Rob Atkinson and the Hassad team for allowing NSW DPI to conduct the experiment on 'Pine Park' Canowindra NSW.

Effect of seeding rate on spring wheat sown mid-April—Canowindra 2014

Colin McMaster, Rob Dunkley NSW DPI, Cowra and Eric Koetz NSW DPI, Wagga Wagga

Key findings

- Grain yield increased by 225 kg/ha by reducing seeding rate.
- Lancer and Bolac were the highest yielding varieties.
- Longer season varieties tended to produce more tillers/m^2 than shorter season wheat varieties.
- The 2014 season was characterised by a dry spring.

Introduction

Research has identified that controlling summer weeds during the summer fallow period can lead to significant increases in stored plant available water and mineral nitrogen, which can then be used for the following winter crop. If seasonal conditions allow, early sowing has been identified as a potential option to convert the moisture and nitrogen into additional grain yield compared to main season and later sowings.

Therefore, the aim of this experiment was to evaluate how different spring wheat varieties respond to seeding rate from a mid-April sowing. Wheat varieties ranged from very slow- to mid-maturity types.

Site details

Location	"The Pines" Canowindra NSW
Soil type	Clay loam
Previous crop/s	Canola (2013)
Stubble management	Stubble incorporated
Harvest date	21 November
Fertiliser	20 kg P/ha + 50 kg N/ha at GS32
Fungicide	Flutriafol treated fertiliser (400 mL/ha) Prosaro (200 mL/ha) applied @ GS39
Soil pH_{Ca}	6.4
In-crop rainfall	192 mm

Treatments

Target plant density	60 plants/m^2 120 plants/m^2 180 plants/m^2
4 wheat varieties	Bolac, EGA_Eaglehawk (very slow), Lancer (slow) and EGA_Gregory (mid).

Rainfall during the months of August, September and October was 43, 17 and 17 mm less than the long-term median rainfall (*Table 1*).

Results

Plant establishment

Plant establishment was significantly affected by seeding rate (P<0.001) and variety (P<0.001) (*Table 2*). The interaction between variety and seeding rate was not significant (P=0.987).

When averaged over all four varieties, plant establishment increased as the seeding rate increased. Target plant density treatments of 60, 120 and 180 plants/m^2 achieved densities of 63, 110 and 151 plants/m^2 (*Table 3*).

Lancer had approximately 13 fewer plants establish than EGA_Eaglehawk, EGA_Gregory and Lancer (*Table 4*).

Table 2: Impact of seeding rate on plant establishment, tiller number and grain yield at Canowindra in 2014.

Target plant population (plants/m^2)	Plant establishment (plants/m^2)	Tiller number (tillers/m^2)	Grain yield (tg/ha)
60	63	509	3.92
120	110	544	3.77
180	151	605	3.70
l.s.d (P=0.05)	6.8	28	127

Tiller counts

The number of tillers was significantly affected by seeding rate (P<0.001) and variety (P<0.001). The interaction between seeding rate and variety was not significant (P=0.566)

Averaged across the four varieties, tillers increased as the seeding rate increased. Tiller number increased from 509, 544 to 605 tillers/m^2 with the respective target density of 60, 120 and 180 plants/m^2 (*Table 3*).

The longer season spring wheats such as Bolac and EGA_Eaglehawk established more tillers (per m^2) than the shorter season varieties EGA_Gregory and Lancer (*Table 4*).

Table 1: Monthly rainfall at Canowindra, 2014.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall (mm)	24	12	36	43	28	20	51	3	24	31	83	99
Median	49	35	32	32	37	49	47	48	41	48	42	42

Table 3: Impact of variety on plant establishment, tiller number and grain yield at Canowindra in 2014.

Variety	Plant establishment (plants/m^2)	Tiller number (tillers/m^2)	Grain yield (t/ha)
Bolac	111	604	4.20
EGA_ Eaglehawk120	113	561	3.53
EGA_Gregory	109	529	3.27
Lancer	98	516	4.19
l.s.d (P=0.05)	7.8	32	0.15

Grain yield

Wheat grain yield was significantly affected by seeding rate (P=0.003) and variety (P<0.001). There was no significant interaction between variety and seeding rate (P=0.243) in this experiment.

Grain yield reduced as seeding rate increased, with yield penalties of 225 kg/ha by sowing the highest seeding rate (*Figure 1*).

Bolac (4.20 t/ha) and Lancer (4.19 t/ha) were the highest yielding varieties, followed by EGA_Eaglehawk (3.53 t/ha) and then EGA_Gregory (3.27 t/ha) (*Table 4*).

EGA_Gregory was sown approximately two weeks earlier than the suggested sowing time, and therefore should not be considered for mid-April sowing time.

Summary

The results from this experiment supports the long-standing central west NSW principle of sow early–sow light. This theory seems to hold for central eastern NSW as well.

If season conditions allow an early sowing opportunity, seeding rates can be reduced as the plant appears to have time to adjust tiller number, grains per head and grain size depending on seasonal conditions.

Acknowledgements

This experiment is part of the *Variety specific agronomy package* project (DAN00167, 2013–2017), jointly funded by GRDC and NSW DPI.

Support from Peter Watt (Elders, Cowra) and Peter Wilson (Lachlan Fertiliser, Cowra) are gratefully acknowledged in assisting with harvesting this experiment.

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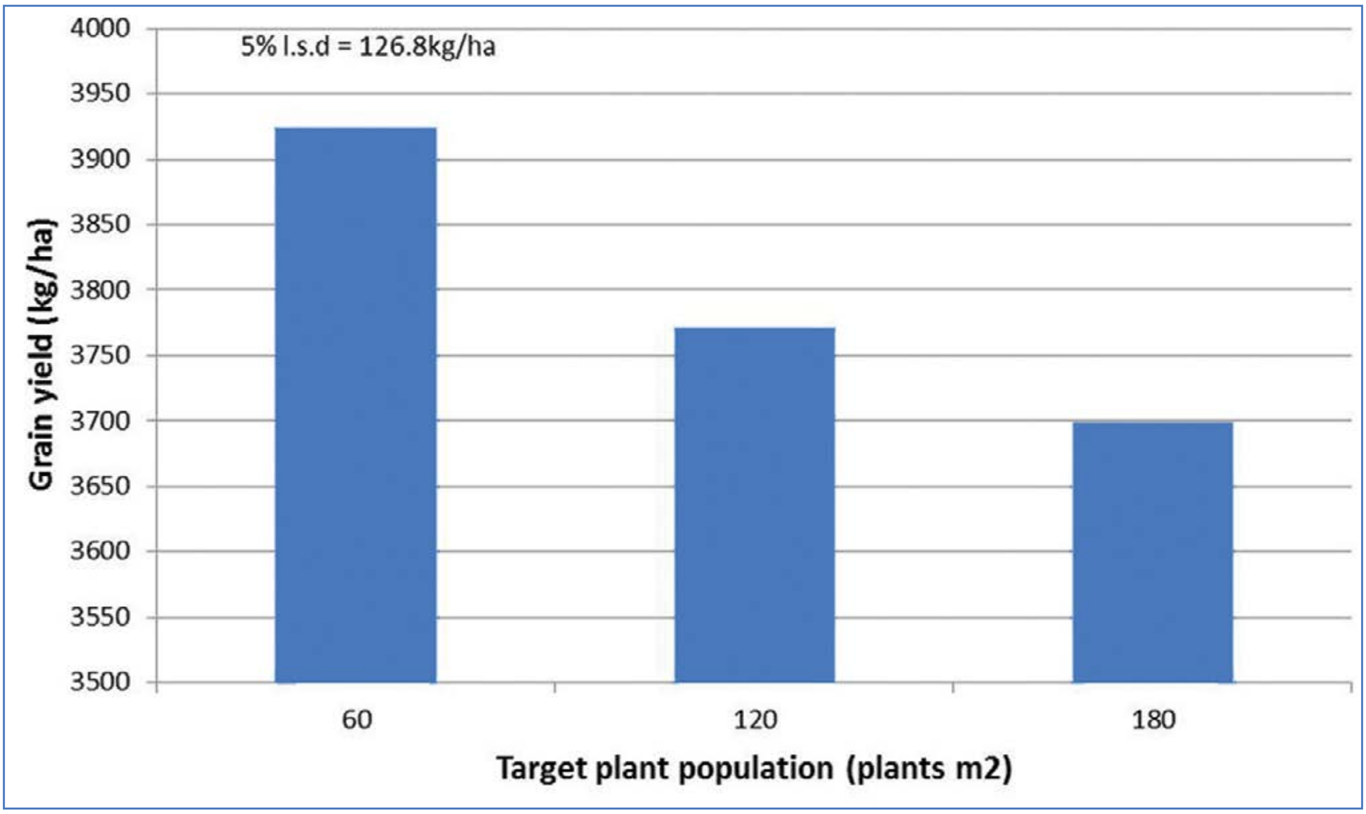

Figure 1: Average grain yield of four varieties sown at three plant populations at Canowindra 2014.

Identification of heat tolerant durum and common wheat germplasm under field conditions

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Introduction

In the Australian wheat belt, periods of moderate to extreme high temperatures are occurring with increasing frequency, particularly during the flowering and grain-filling stages of crop growth. Wheat (*Triticum aestivum*) is very sensitive to high temperature, and yields can drop ~3–4% with every 1°C increase in temperature above the optimum. With global warming predictions, the frequency and magnitude of heatwaves in the southern Australian wheat belt are expected to increase, making heat stress an increasing threat to sustaining wheat yields. Varieties with improved tolerance would be highly desirable, but heat tolerance is a difficult trait for the wheat breeder to work with, because it is genetically and physiologically complex, and because natural episodes of heat in the field are almost invariably accompanied by water deficit.

This study reports the identification of heat tolerant durum and bread wheat germplasm in trials carried out under natural field conditions. Delayed sowing with irrigation was used to expose plots to heat stress, as planting at different times during the year exposes the crop to different temperatures during its life cycle and can provide an indication of crop response to temperature without artificial conditions imposed by controlled environments.

Site details

Location	WWAI irrigation area, Wagga Wagga; Leeton Farm Station, Leeton
Trial period	2011–2013
Collaborators	ACPFG, University of Adelaide; Tamworth Agricultural Institute, Calala
Heat events*	WWAI, Normal sowing: 1.5 WWAI, Late sowing: 4.5 LFS, Normal sowing: 2.0 LFS, Late sowing: 6.0

* A heat event is defined as a block of two or more days with T °C>30

Key findings

- Considerable genetic variation was observed for heat tolerance under late-season planting.
- In general, heat stress reduced yield and single-grain weight, shortened the time to anthesis, and made the plants shorter by an average of ~20 cm.
- The most heat-tolerant durum types were Kalka and Caparoi, while amongst the hexaploid varieties, Sokoll, Halberd and Excalibur were ranked as heat tolerant.
- The next step is to validate the results under managed environments using the Managed Environment Facilities.
- Identify varieties able to maintain grain yield and bread-making quality under heat stress.

Treatments

Wheat genotypes

260 **wheat genotypes** were used, comprising:

- 215 common wheat, and
- 45 durum genotypes.

The genotypes represent:

1. Current elite wheat cultivars;
2. CIMMYT's HTWYT wheat; and
3. Global landrace varieties obtained using FIGS (Mackay *et al.* 2004; Bhullar *et al.* 2009).

Sowing dates

1. First week of June (normal) treatment,
2. First week of August (heat-stressed) treatment.

Results

Flowering time was a strong driver of relative performance, both within and between sowings – a factor that needed to be considered when estimating each genotype's heat tolerance. In general, late-season heat stress reduced yield and single-grain weight (SGW), shortened the time to anthesis, and made the plants shorter by an average of ~20 cm. The reduction in growth duration was more pronounced (by 2 to 3 days) in the durums than in the elite hexaploids of the same flowering time range. This may either represent 'constructive avoidance' of heat stress by the durums or 'heat maladaption' (feeling more stressed), when compared with the hexaploids.

Tolerance was quantified using an index, which adjusts for spatial variation, flowering time, and foliar

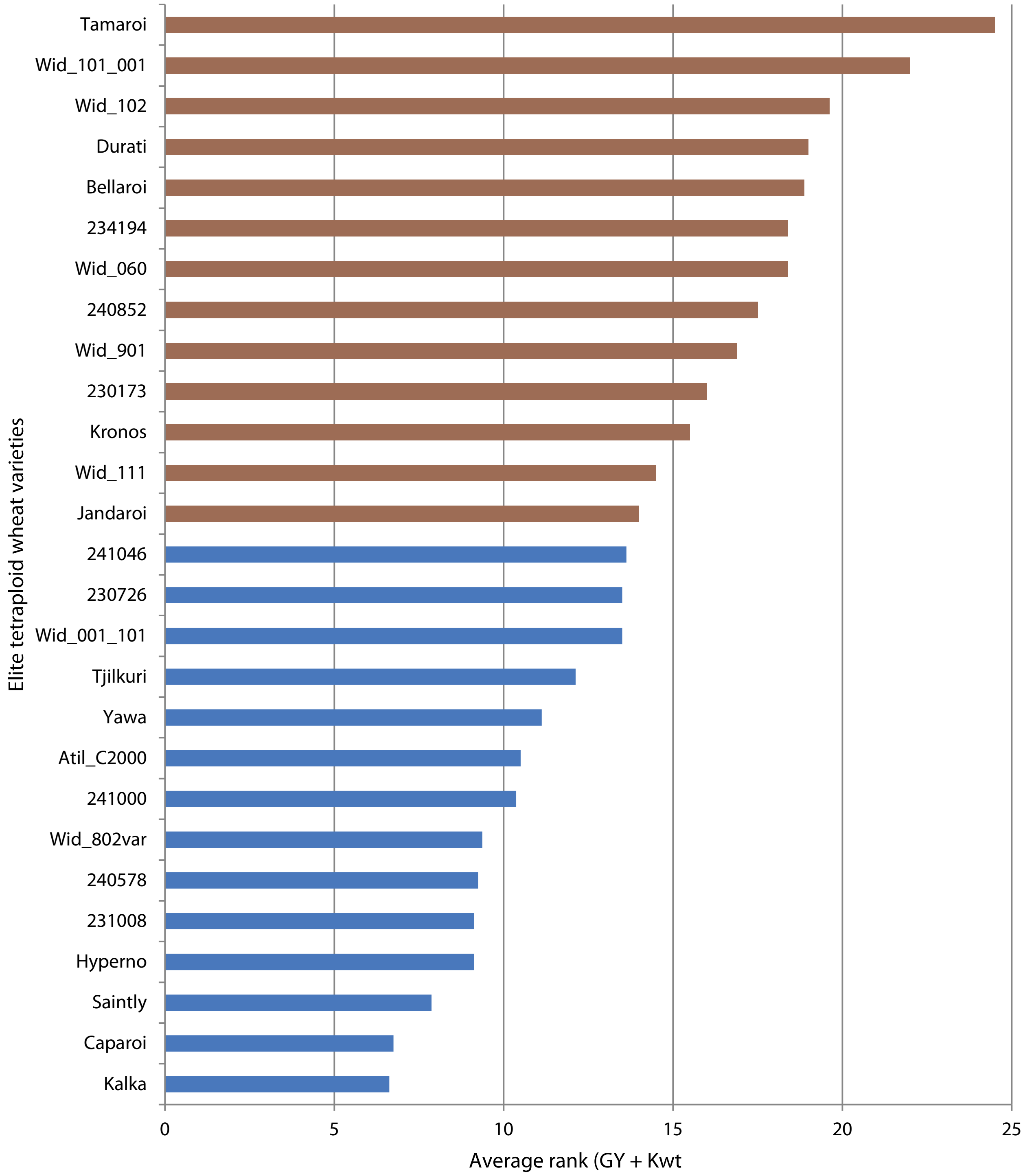

Figure 1A: Heat tolerance rankings of selected tetraploid (durum) wheat varieties, as defined by performance under heat stress (late-season) versus normal sowings, in field trials at Leeton and Wagga Wagga, NSW, during the 2011 and 2012 seasons.

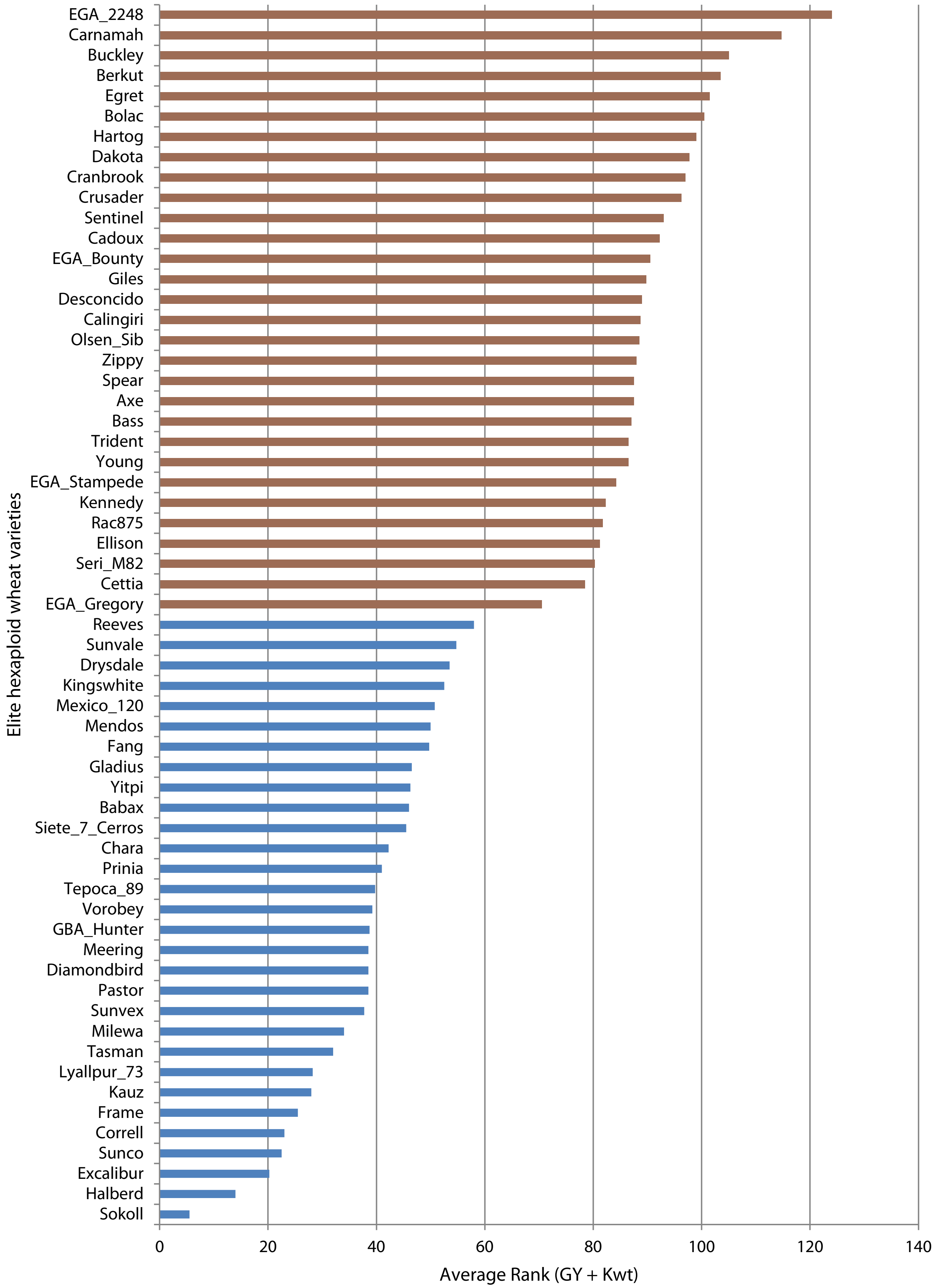

Figure 1B: Heat tolerance rankings of selected hexaploid (common) wheat varieties, as defined by performance under heat stress (late-season) versus normal sowings, in field trials at Leeton and Wagga Wagga, NSW, during the 2011 and 2012 seasons.

disease. Using this assay, considerable genetic variation was observed for heat tolerance, perhaps reflecting the wide range of diversity in germplasm used for the study. In general, lines bred at the International Maize and Wheat Improvement Center (CIMMYT) were among the most heat-tolerant hexaploid types identified (unpubl.). The most heat tolerant durum types identified were Kalka and Caparoi, while Tamaroi was ranked as heat sensitive (*Figure 1A*). Amongst the Australian elite hexaploid varieties, those ranked by the field-based assay as heat tolerant include Excalibur and Sunco, while EGA-2248 and Carnamah were ranked as heat sensitive (*Figure 1B*). Additional reports are presented in GroundCover (2015).

Future Directions

In 2014, the best performing lines were tested for consistency at the GRDC's Managed Environment Facilities (MEFs) at Merredin (Western Australia), Yanco and Narrabri (NSW). The data from these trials are currently being analysed. Grain samples from the field experiments are being used to identify varieties able to maintain better grain quality under heat stress. There are also concerns that using late sowings with irrigation is not representative of commercial field production environments. Accordingly, another set of trials are planned for the future, designed to quantify yield benefits of heat tolerant germplasm by growing identified varieties under various naturally occurring heat scenarios in different Australia wheat-growing regions.

Summary

Considerable genetic variation was observed for all measured traits, when heat tolerance was defined as relative varietal performance in late versus normal sowings (*Figure 1*). There is need to exploit this level of genetic variation in order to provide growers with wheat varieties able to sustain production against predicted increases in extreme heat events. Our current activities are focused on extensive field trials, aimed at developing robust molecular markers, which can be used by breeders as surrogates to side-step the difficulties of selecting for heat tolerance.

Acknowledgements

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Crown rot variety trials—southern NSW 2014

Dr Andrew Milgate NSW DPI, Wagga Wagga

Introduction

The aim of the experiment was to examine the effect of crown rot on yield and basal stem infection in 13 wheat and 5 barley varieties of differing resistance levels in southern NSW.

Site details

Wagga Wagga and Cowra were selected as being representative of the medium to high rainfall southern NSW winter cropping regions.

Varieties

Eighteen locally relevant varieties with a range of resistance to crown rot were used, see *Table 1*.

Crown rot inoculation

Trials were inoculated with a mixture of isolates collected from southern NSW.

Treatments

There were two treatments:

1. Crown rot added: 72 g of crown rot infected non-viable seed sown per plot with viable seed.
2. No crown rot added: no crown rot inoculum sown in plots.

All plots were sown with Jubilee® (flutriafol 250 g/L) at 800 mL/ha treated fertiliser and foliar sprays of Bumper® (propiconazole 250 g/L) at 500 mL/ha as required to ensure foliar disease control.

Results

Disease severity

Incidence of basal browning was high in all trials irrespective of treatment (data not shown). The severity of basal browning differed significantly between the treatments and varieties. Basal browning was more severe at Cowra than at Wagga. The ranking of barley varieties across both sites was similar (*Figure 1A* and *1B*). Buloke and GrangeR had higher severity scores than Commander, Hindmarsh and Compass. At Cowra for the barley varieties there was little difference in severity between the crown rot treatment and no added crown rot.

For the wheats the ranking of varieties changed between the two sites. This was mainly due to EGA_Gregory and EGA_Wedgetail shifting from having low severity at Wagga to high levels at Cowra. The varieties which showed lower levels of severity at both sites were Lancer, Elmore CL Plus and Emu Rock.

Table 1: Varieties included in crown rot trials 2014.

Variety	Cr rating#	Variety	Cr rating#
GrangeR	SVS	Phantom	MSS
Buloke	SVSP	Impala	MSN
Compass	SP	Elmore CL Plus	MSSP
Commander	SP	Lancer	MSS
Himdmarsh	MRMS	Trojan	MSS
EGA_Gregory	S	Merlin	MS
Suntop	MSS	Emu Rock	MSS
EGA_Wedgetail	MSS	Sunguard	MS
Waggan	SP	Bellaroi	VS

Crown rot rating as published in the NSW DPI Winter crop variety sowing guide 2014.

Yield

The addition of crown rot caused significant yield loss in most varieties included in the trials. The highest losses of 42% were experienced by the VS durum variety Bellaroi at Wagga (*Figure 2*). There were significant differences in the performance of varieties both in the presence of crown rot and without it. This resulted in some high yielding varieties such as Compass yielding more in the presence of crown rot than a variety like Buloke without crown rot present. Similarly for the wheats at Wagga where Emu rock performed very well in the presence of crown rot with little yield loss and was higher yielding than many of the other varieties without crown rot added. At Cowra the performance in the presence of crown rot was more even across varieties, only Lancer and EGA_Wedgetail had lower yield than the other 10 bread wheats

Table 2: Sowing and fungicide application dates in 2014.

Location, experiment	Sowing date	Fungicide application date
Wagga Wagga, dryland	10 June	12 September
Cowra, dryland	18 June	15 September

Key findings

- High yield losses of up to 42% due to crown rot observed in 2014.
- None of the tested varieties show high levels of resistance.
- A number of varieties appear to have higher yields in the presence of disease.
- Selecting the highest yielding varieties rather than crown rot resistance to minimise losses remains the current advice to growers.
- Reduce the risk of crown rot infection by using rotation and stubble management.

(*Figure 3*). The winter wheat EGA_Wedgetail was affected by the late sowing time of these trials and poor spring rainfall.

Summary

The dry spring conditions of 2014 suited the expression of crown rot in southern NSW, the combination of high infection rates and lack of moisture resulted in the observed yield losses. These results show that some varieties do vary in their ability to yield in the presence of crown rot at different locations. There are a number of promising varieties highlighted in these trials, however this is only one year of results and will require repeating for confirmation. The current recommendation remains that growers should select varieties for the best yield in their area and minimise crown rot inoculum in paddocks through good rotation as none of the varieties are resistant.

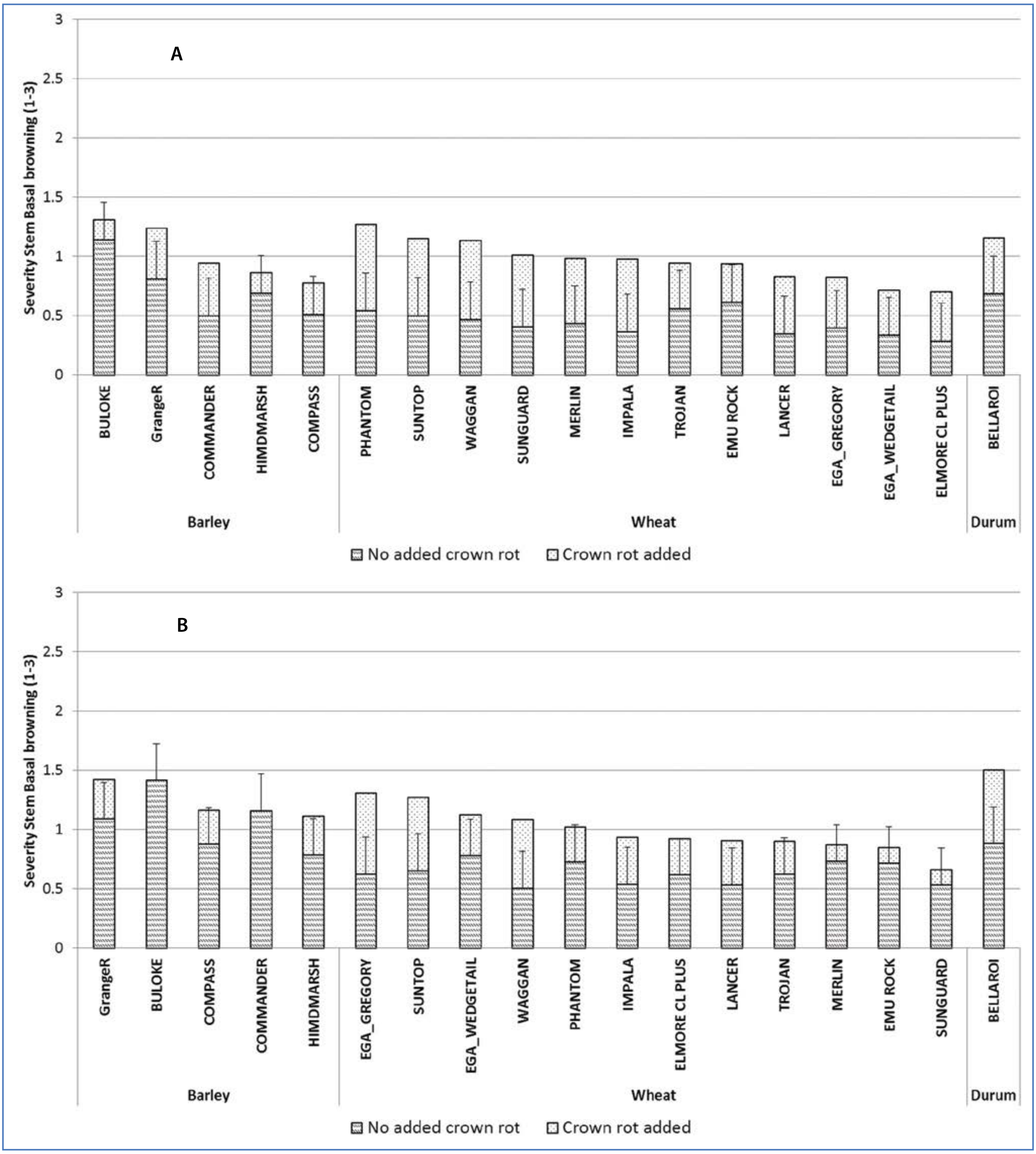

Figure 1: Severity of crown rot Wagga Wagga (A) error bars displayed are LSD = 0.32 and Cowra (B) error bars displayed are LSD = 0.31, 2014 variety trial.

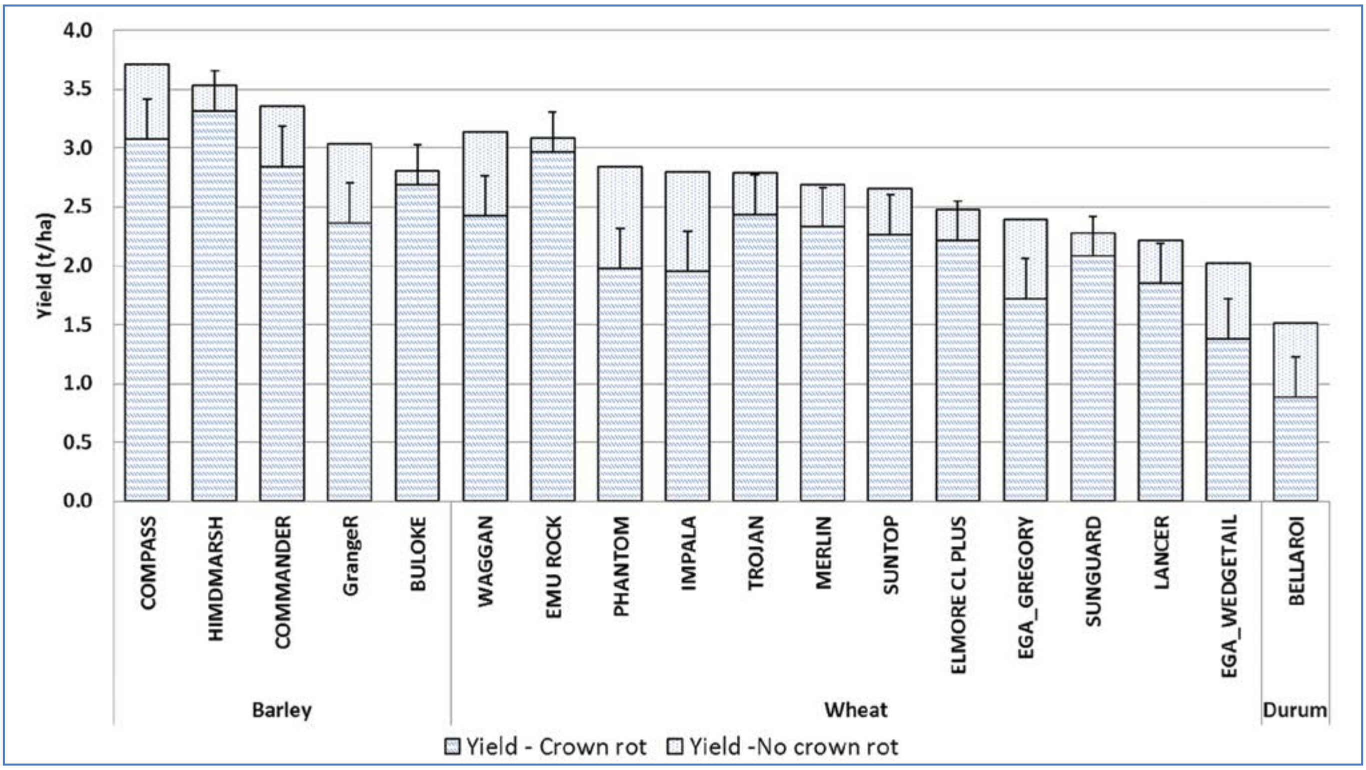

Figure 2: Crown rot variety yield trial Wagga Wagga 2014. Error bas show LSD at 5%= 0.345 t/ha.

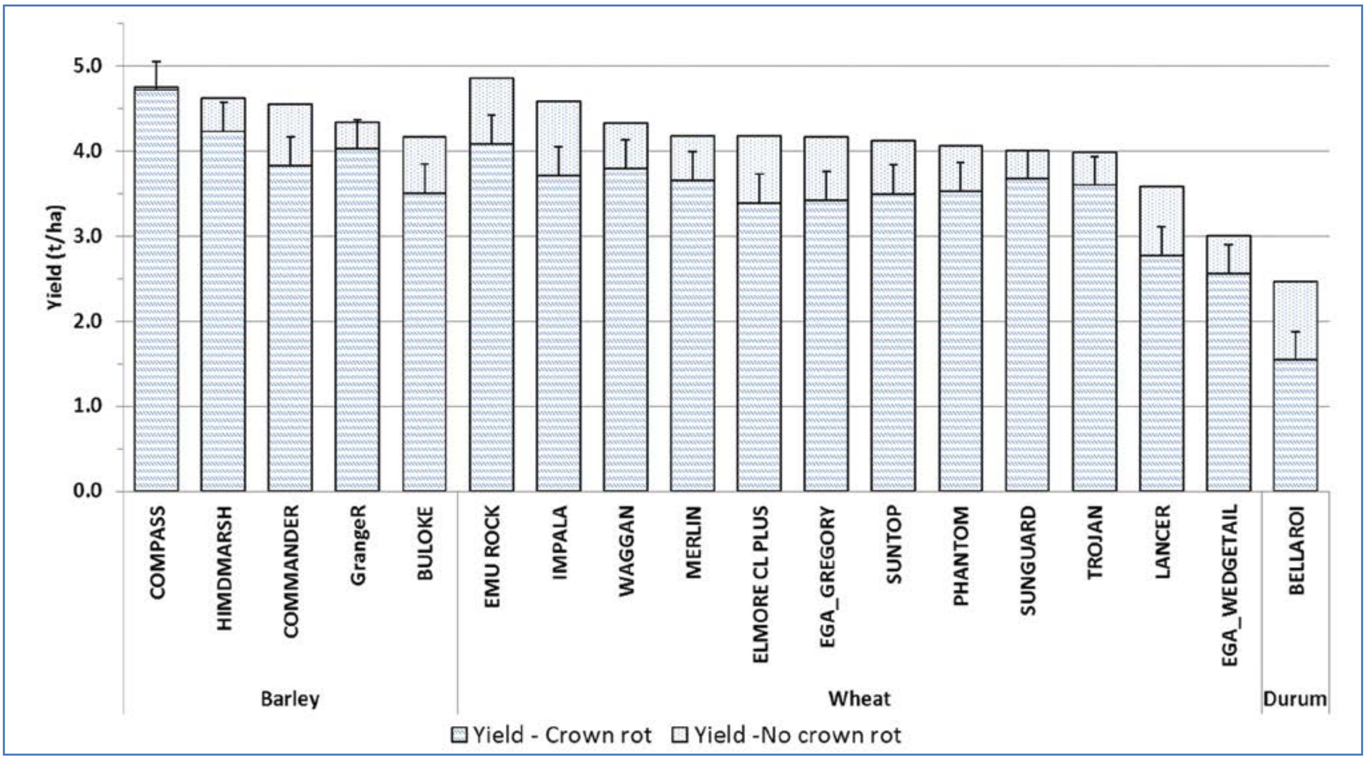

Figure 3: Crown rot variety yield trial Cowra 2014. Error bas show LSD at 5%= 0.283 t/ha.

Note: This is an industry summary provided pre-publication. Further information and analysis will be published in due course.

Acknowledgements

The *National crown rot program* (DAN00175, 2013–2018) and *Improving Grower Surveillance, Management, Epidemiology Knowledge and Tools to Manage Crop Disease in southern NSW* (DAN00177, 2013–18) are jointly funded by GRDC and NSW DPI. The aim is to reduce the impact of crop diseases.

All technical components of conducting these experiments were carried out by Mr Tony Goldthorpe and Mr Michael McCaig.

Yellow leaf spot variety trials—southern NSW 2011–13

Dr Andrew Milgate NSW DPI, Wagga Wagga

Introduction

The aim of the experiment was to examine the effect of yellow leaf spot (YLS) infection on grain yield and its control with fungicide in 15 wheat varieties of differing resistance levels in southern NSW.

Site details

Wagga Wagga and Cowra were selected as they are representative of the medium to high rainfall, winter cropping regions of southern NSW. The Wagga Wagga site also has access to overhead irrigation which could be used to promote disease in trials.

Varieties

Fifteen locally relevant varieties with a range of resistance to YLS were selected (*Table 1*). Varieties with adequate stripe rust resistance were selected to reduce confounding effects from this disease.

Yellow leaf spot isolate

Trials were inoculated with an isolate collected from southern NSW. In addition YLS infected stubble was applied to disease plots at GS 12–15, at a rate of 1 kg/m^2.

Treatments

There were two treatments (*Table 2*).

Fungicide treatment (see *Table 2* for timing of treatments)	2011 and 2012: multiple applications of Bumper® (propiconazole 250 g/L) 500 mL/ha
	2013: Amistar Xtra® (azoxystrobin 200 g/L + cyproconazole 80 g/L) 400 mL/ha followed by two applications of Bumper® (propiconazole 250 g/L) 500 mL/ha
Disease treatment	Received no foliar fungicide applications

All plots were sown with Jubilee® (flutriafol 250 g/L) at 400 mL/ha (2011) and 800 mL/ha (2012–13) treated fertiliser to ensure stripe rust control.

Key findings

- Fungicide reduced YLS levels in most trials but failed to eliminate the disease completely.
- Observed differences in disease levels were broadly in agreement with published variety resistance ratings.
- Yield losses were observed in the more susceptible varieties at moderate infection levels.
- Frost events in October 2013 caused variable damage to varieties and impacted on yield comparisons.
- At Wagga Wagga in 2011 and 2012, and Cowra in 2013 low disease levels in trials despite inoculations resulted in no significant yield loss associated with disease.

Table 1: Varieties included in YLS trials 2011–13.

Variety	YLS rating#	Variety	YLS rating#
Axe	S	Strzelecki	MS
Bolac	S	Sunbri	MS
EGA_Gregory	MSS	Sunlin	MS
EGA_Wedgetail	MSS	Sentinel 3R	MS
EGA_Bounty	MS	Sunvale	MSS
Espada	MS	Sunvex	MRMS
Lincoln	MS	Zebu	-
Livingston	MS		

As published in the NSW DPI Winter crop variety sowing guide 2014.

Results

Disease severity

Disease severity was monitored during the season and assessed using a 1–9 CIMMYT scale. This scale assesses how far disease moves up the canopy and its severity. A score of 1 represents disease restricted to the lower leaves and a low percentage infection. A score of 9 represents disease has reached the head and destroyed 90%–100% of the flag leaf.

Disease development across the trials varied markedly. Seasonal factors influenced the pattern of disease severity within each of the trials. For example, the dry

Table 2: Sowing and fungicide application dates.

Year	Location	Experiment	Sowing date	Fungicide application dates
2011	Wagga Wagga	Dryland	19 May	1/8, 2/9, 3/10
2012	Wagga Wagga	#Supplementary spring irrigation	10 May	3/8, 10/9, 11/10
2013	Cowra	Dryland	19 June	11/9, 11/10
	Wagga Wagga	Dryland	10 May	26/7, 24/8, 22/9
	Wagga Wagga	§Irrigated	10 May	26/7, 24/8, 22/9

Three supplementary spring irrigations of 20 mm (12/9, 25/9, 18/10) applied to experiment to ensure it produced results.
§ Irrigation applied to promote disease in experiment; timing and rate varied in response to seasonal factors.

spring conditions at Wagga Wagga in 2011 (data not shown) and 2012, and also at Cowra in 2013 reduced how far up the canopy the disease reached. While in 2013 conditions were more favourable for disease development at Wagga Wagga (*Figure 1*).

Yellow leaf spot is spread within a crop by rain splash and wind-dispersed asexual spores called conidia. Conidia require a period of leaf wetness of at least six hours for infection to occur. Thus extended periods of dry weather during stem elongation significantly reduces the impact of the disease. This helps to explain the differences in severity between trials seen in *Figure 1*, with the 2013 Cowra dryland experiment having lower scores (maximum 3), and the disease restricted to the lower leaves at the base of the plant while in the Wagga Wagga irrigated 2013 experiment the maximum score was 6.5, with the disease reaching the flag minus one leaf.

Yellow leaf spot was more severe on varieties with lower resistance levels. This was most evident in the 2013 irrigated experiment and to a lesser extent in the 2013 Wagga Wagga dryland experiment (*Figure 1*). Axe and Bolac are rated Susceptible (S) and developed the highest level of disease in 2013 along with EGA_Gregory and EGA_Wedgetail which are rated as Moderately Susceptible to Susceptible (MS-S).

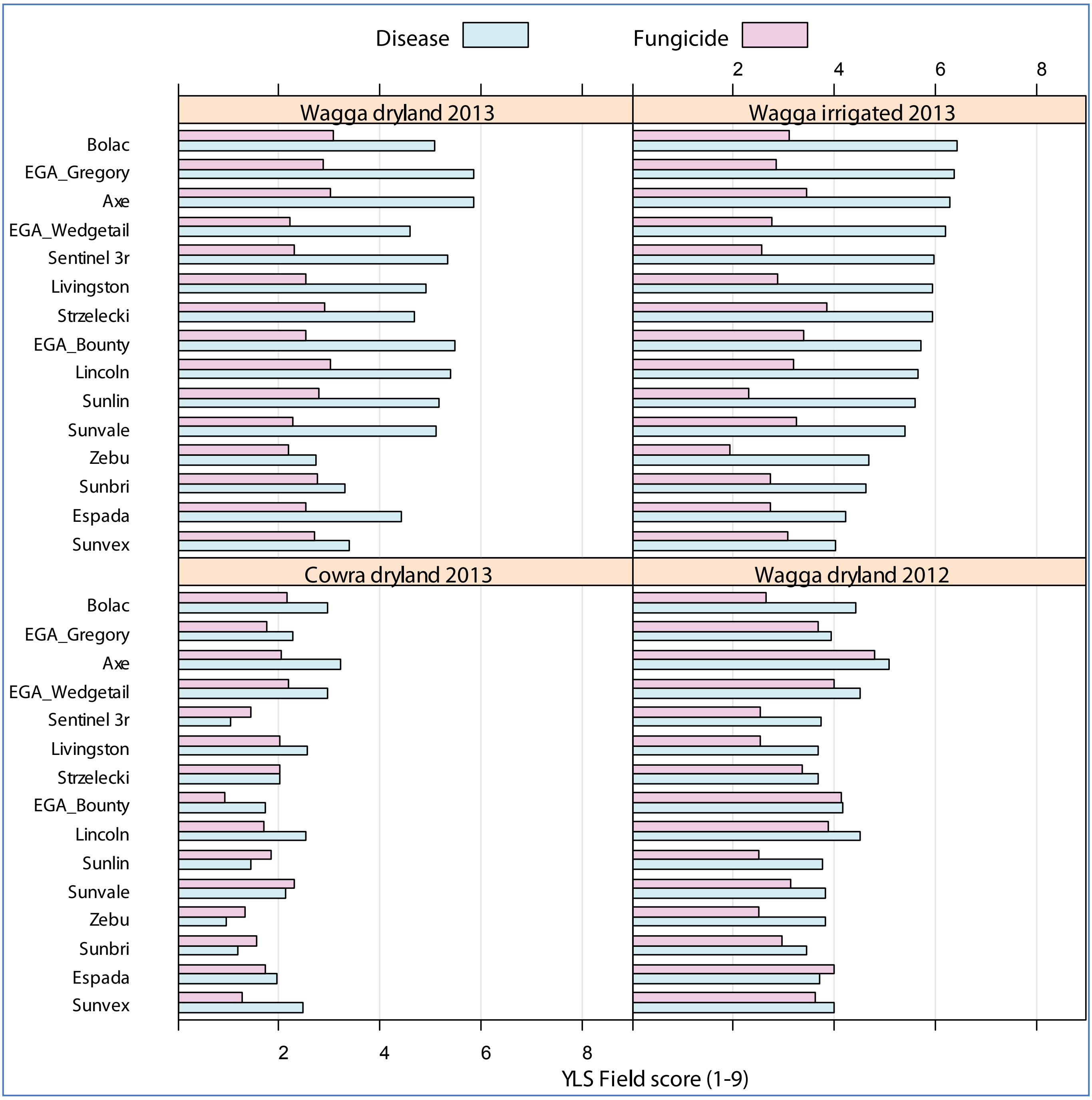

Figure 1: Yellow leaf spot disease levels in variety trials conducted at Wagga Wagga and Cowra 2012–13. (Least significant difference at 5% = 0.76).

Sunvex and Espada showed the lowest levels of disease development in 2013. However, the disease still reached flag minus three leaf (*Figure 1* scores of 4). This is in line with their disease ratings of MR-MS and MS suppressing disease damage but not being completely resistant.

The effectiveness of the fungicide treatment to control this type of necrotrophic disease is also illustrated in *Figure 1*. The aim of the fungicide treatment was to control the disease and avoid any impact on yield. By restricting the disease severity to scores of 4 or less this was achieved. However, the result also shows that fungicides do not completely kill YLS once an infection has occurred despite repeated applications.

Shortly after infection, necrotrophic diseases such as YLS kill living plant cells and feed on them. This makes them difficult to target with azole fungicides because there is no or little translocation of the fungicide into the dead leaf area.

Yield

Yield loss in these trials was variable. *Figure 2* shows the average yield achieved for each variety for the 2012 and 2013 trials (multi-environment analysis). While

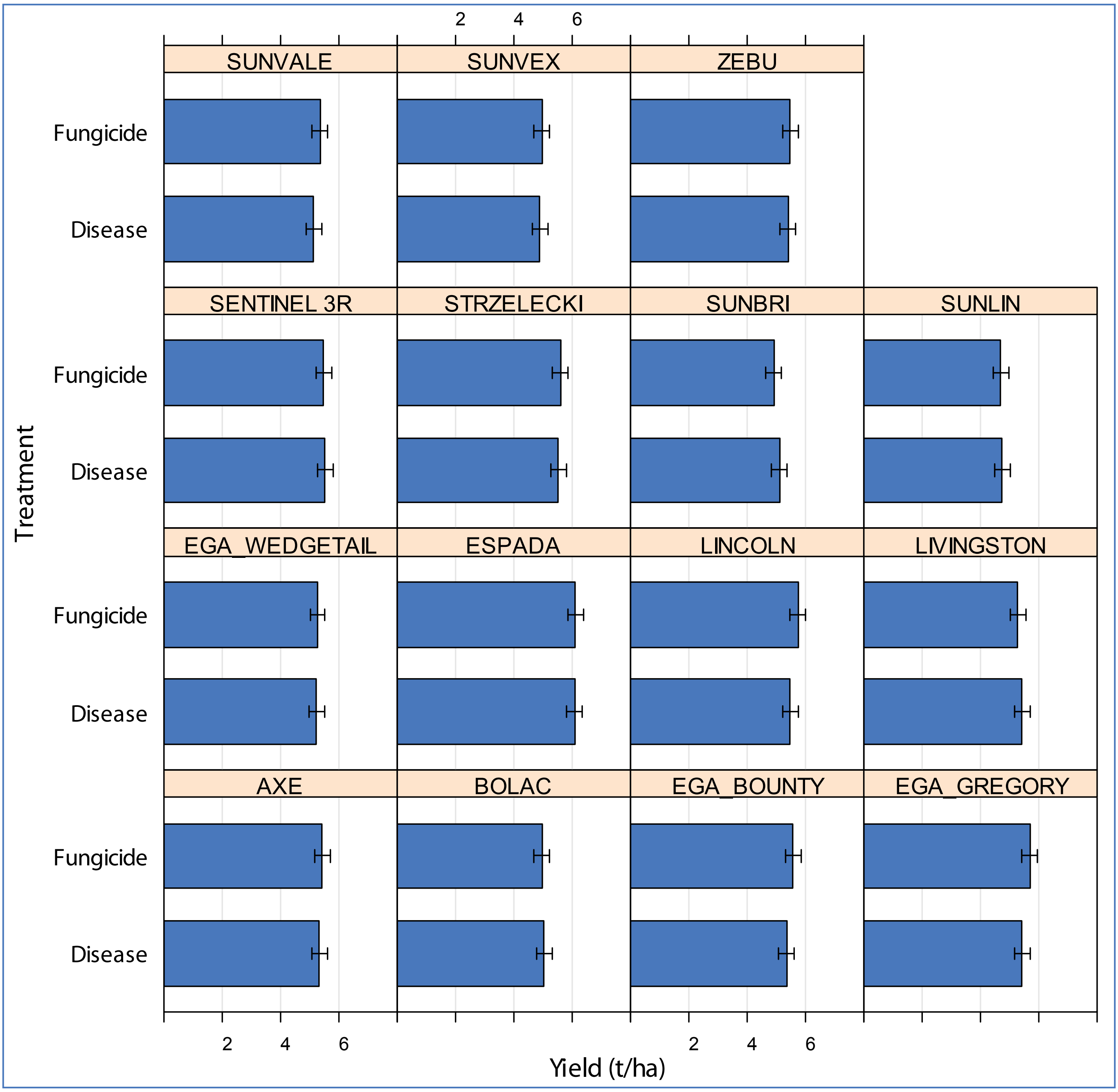

Figure 2: Comparison of grain yield (t/ha) in the presence of yellow leaf spot in four trials conducted in southern NSW from 2012–13 at Wagga Wagga and Cowra (4 experiment MET analysis). Error bars are least significant difference at 5%, if the bars do not overlap a mean this indicates a significant difference between treatments.

statistically there are significant differences between the treatments for a number of varieties, they are small.

By examining each of the trials individually, we can see the relationship of yield to disease severity in *Figure 3*. This figure again highlights that significantly different disease severity occurred between the two treatments (except Cowra 2013) but this did not translate into large yield impacts. The reasons for this include the dry spring conditions of 2012 and the 2013 frost events confounding variety yields.

Benefits of fungicide control of disease can be seen in a number of the varieties, particularly in the 2013 irrigated experiment (*Figure 4*). By calculating the per cent yield response to fungicide treatments in each of the trials it is possible to identify a number of varieties that responded more than others.

The varieties Lincoln, EGA_Gregory, Sunvale and Axe all had positive yield responses in the range of 1%–16% in the Wagga Wagga 2012–13 trials. While the remaining varieties yield responses were more variable. This shows that the more susceptible varieties

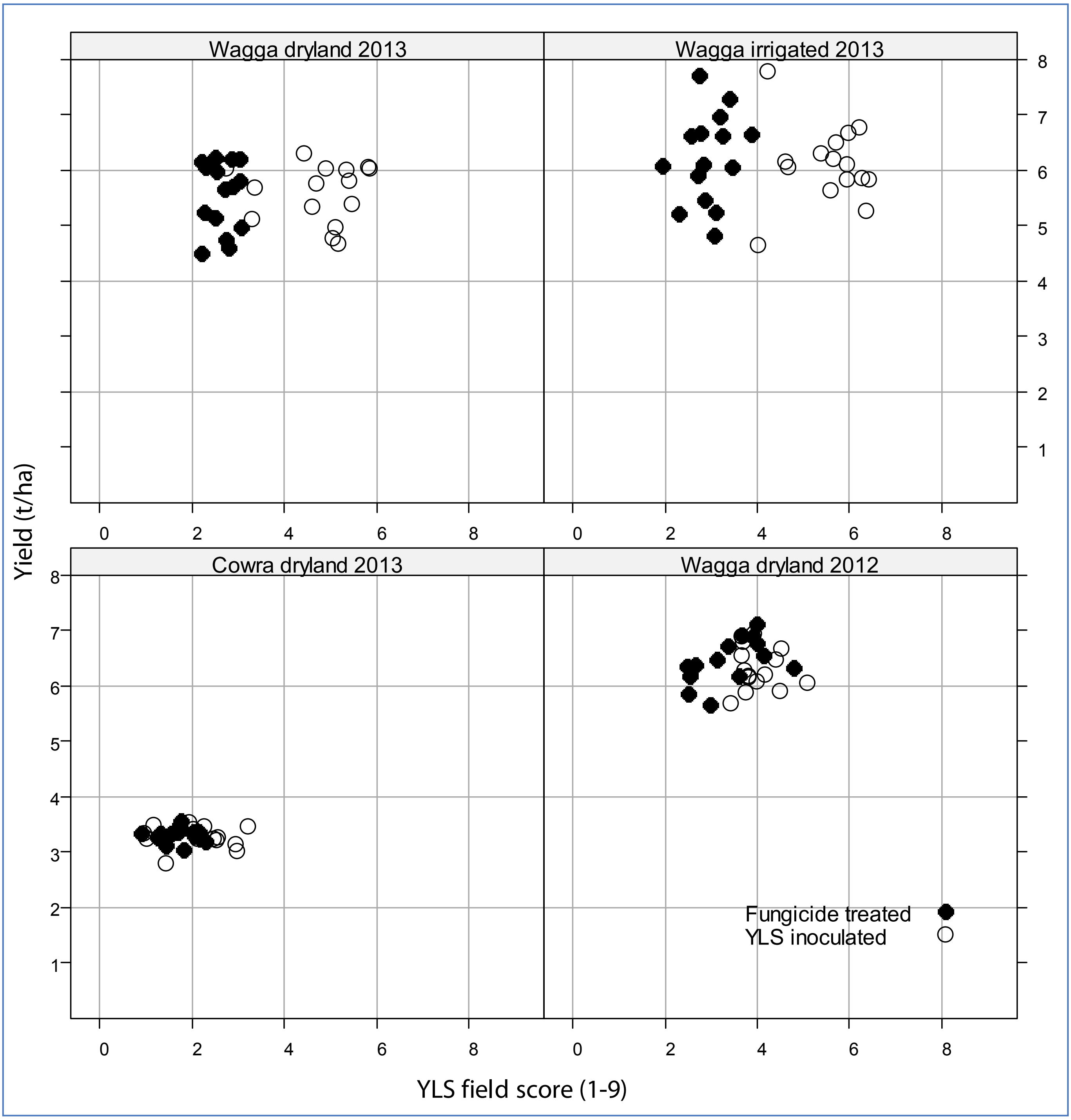

Figure 3: Comparison of disease levels and grain yield (t/ha) for four yellow leaf spot trials conducted in southern NSW from 2012–13 at Wagga Wagga and Cowra.

did suffer yield impacts associated with YLS despite the low infection levels that occurred in some of these trials. However, fungicide application does not always guarantee a yield benefit or neutral effects, for example, the slower maturing lines, EGA_Wedgetail, Bolac and Sunlin, yielded less in the fungicide treated plots for a number of trials than the disease plots. This phenomenon can sometimes occur when varieties develop large canopies in the absence of disease and as a result use the available soil moisture more rapidly, leading to small pinched grain and thus have lower water use efficiency than the disease treatments. This may explain some of the observed effects in these trials but additional factors such as frost may also have contributed to the variation.

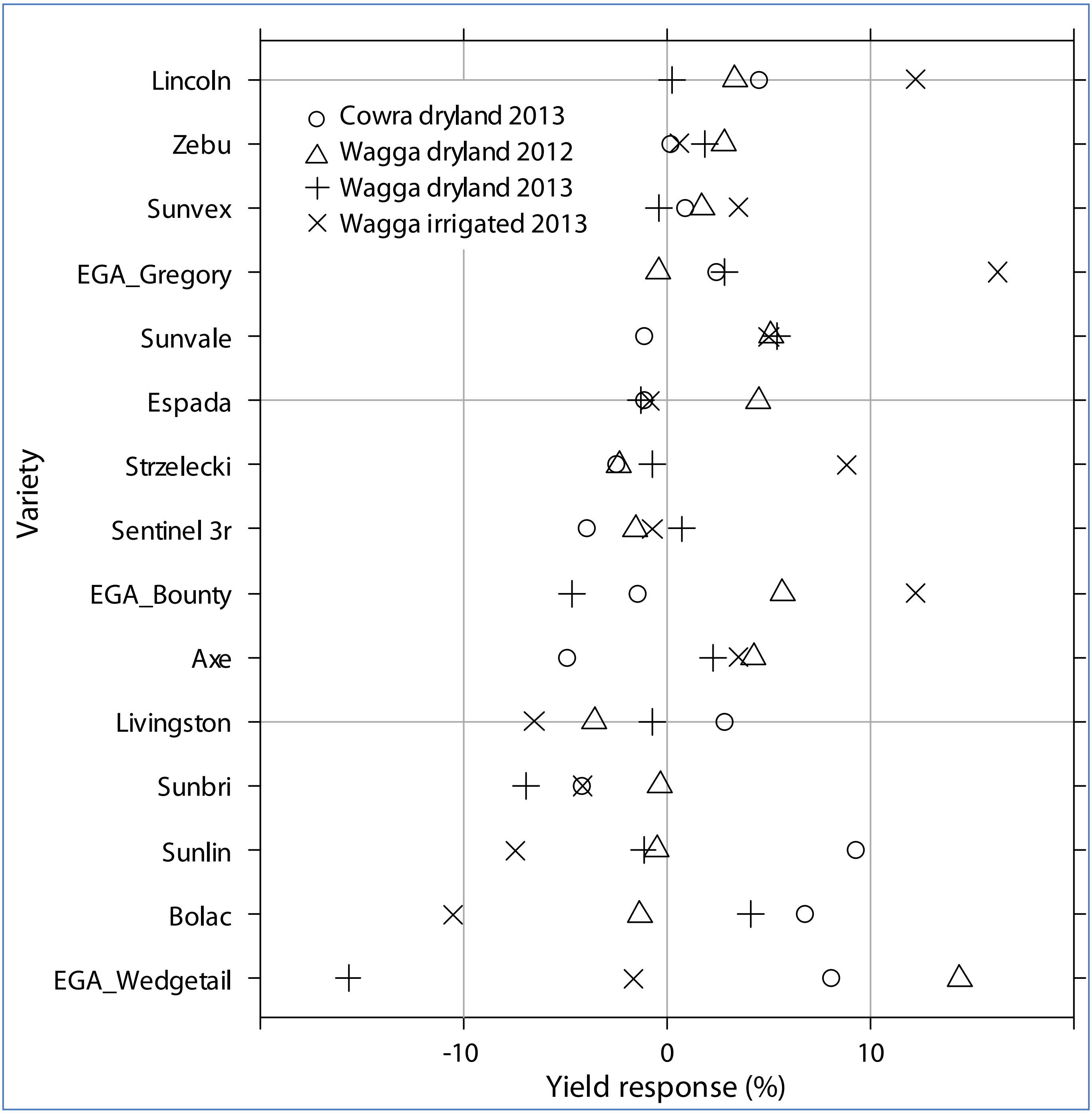

Figure 4: Comparison of percent yield response to fungicide application in three yellow leaf spot trials conducted in southern NSW from 2012–13 at Wagga Wagga and Cowra.

Summary

These results highlight that variety resistance, even at intermediate levels (MRMS), is important in reducing severity of YLS as part of an integrated disease management strategy to avoid losses to this disease.

Complete control of necrotrophic diseases such as YLS with fungicides alone is not possible. Yield responses are highly variable due to seasonal factors affecting disease levels and other abiotic effects such as drought and frost.

Yellow leaf spot is one of the most common foliar wheat diseases in southern NSW occurring frequently at low to moderate levels. Adoption of a more resistant variety in rotations where previous wheat stubbles are carrying high levels of inoculum is required to reduce these losses in a sustainable way.

Note: This is an industry summary provided pre-publication. Further information and analysis will be published in due course.

Acknowledgements

Integrated disease management for cereal and broad leaf crops in southern NSW and north east Victoria (DAN00147, 2010–13); and *Improving grower surveillance, management, epidemiology knowledge and tools to manage crop disease in southern NSW* (DAN00177, 2013–18). Projects are jointly funded by GRDC and NSW DPI and aim to reduce the impact of crop diseases.

All technical components of conducting these experiments were carried out by Mr Tony Goldthorpe and Mr Michael McCaig.

Yellow leaf spot trials—southern NSW 2014

Dr Andrew Milgate NSW DPI, Wagga Wagga

Introduction

The aim of the experiment was to examine the effect of Yellow leaf spot (YLS) on grain yield in three wheat varieties of differing resistance with different fungicide strategies in southern NSW.

Site details

Wagga Wagga and Cowra were selected as being representative of the medium to high rainfall southern NSW winter cropping regions.

Varieties

Three locally relevant varieties with a range of resistance to YLS were used, see *Table 2*. Varieties with adequate stripe rust resistance were selected to reduce confounding effects from this disease.

Yellow leaf spot isolate

Trials were inoculated with an isolate collected from southern NSW. In addition YLS infected stubble was applied to disease plots at GS 12–15, at a rate of 1 kg/m^2.

Treatments

Table 1: The four treatments in the yellow leaf spot experiment.

Full control	Received multiple applications of Bumper® (Propiconazole 250 g/L) at 500 mL/ha
Fungicide at 5 leaf stage	Bumper® (Propiconazole 250 g/L) at 500 mL/ha
Fungicide at GS31+39	Bumper® (Propiconazole 250 g/L) at 500 mL/ha applied growth stage 31 and again at growth stage 39
No fungicide	Control treatment which received no foliar fungicide applications

All plots were sown with Jubilee® (Flutriafol 250 g/L) at 800 mL/ha treated fertiliser to ensure stripe rust control.

Table 2: Varieties included in YLS trials 2014.

Variety	YLS rating#
EGA_Gregory	MSS
Phantom	SVS
Strzelecki	MS

As published in the NSW DPI Winter crop variety sowing guide 2014.

Key findings

- Fungicide reduced disease levels in most trials but failed to eliminate the disease completely.
- Observed differences in disease levels were broadly in agreement with published variety resistance ratings.
- Yield losses were observed in the more susceptible varieties under irrigated conditions.
- Low disease levels in trials despite inoculations resulted in no significant yield loss associated with disease in dryland trials at Wagga Wagga and Cowra in 2014.

Table 3: Sowing and fungicide application dates, 2014.

Location, Experiment	Sowing date	Fungicide application dates
Cowra, Dryland	7 May	17 June, 28 July, 5 September (full control every 3 weeks)
Wagga Wagga, Dryland	8 May	19 June, 8 August, 12 September (full control every 3 weeks)
Wagga Wagga, §Irrigated	8 May	19 June, 8 August, 12 September (full control every 3 weeks)

§ Supplementary spray irrigations applied to promote disease in experiment; timing and rate varied in response to seasonal factors between August and November to ensure conducive disease environment.

Results

Disease severity

Disease severity was highest in the irrigated experiment at Wagga Wagga (*Figure 1*). The epidemic was slow to initiate with most disease expression occurring during October. This reflected the dry late winter and early spring conditions of 2014 which acted to slow the rate of infection by necrotrophic diseases in southern NSW. The dryland trials at Wagga and Cowra clearly show the impact of the dry spring conditions (*Figures 3A* and *3B*). Fungicide treatment effects on disease progression were noticeable only in the SVS variety Phantom in the irrigated experiment. The early season application at 5 leaf stage alone did not provide a lasting effect on the disease progression. The GS31+39 spray combination gave similar results to the full control treatment.

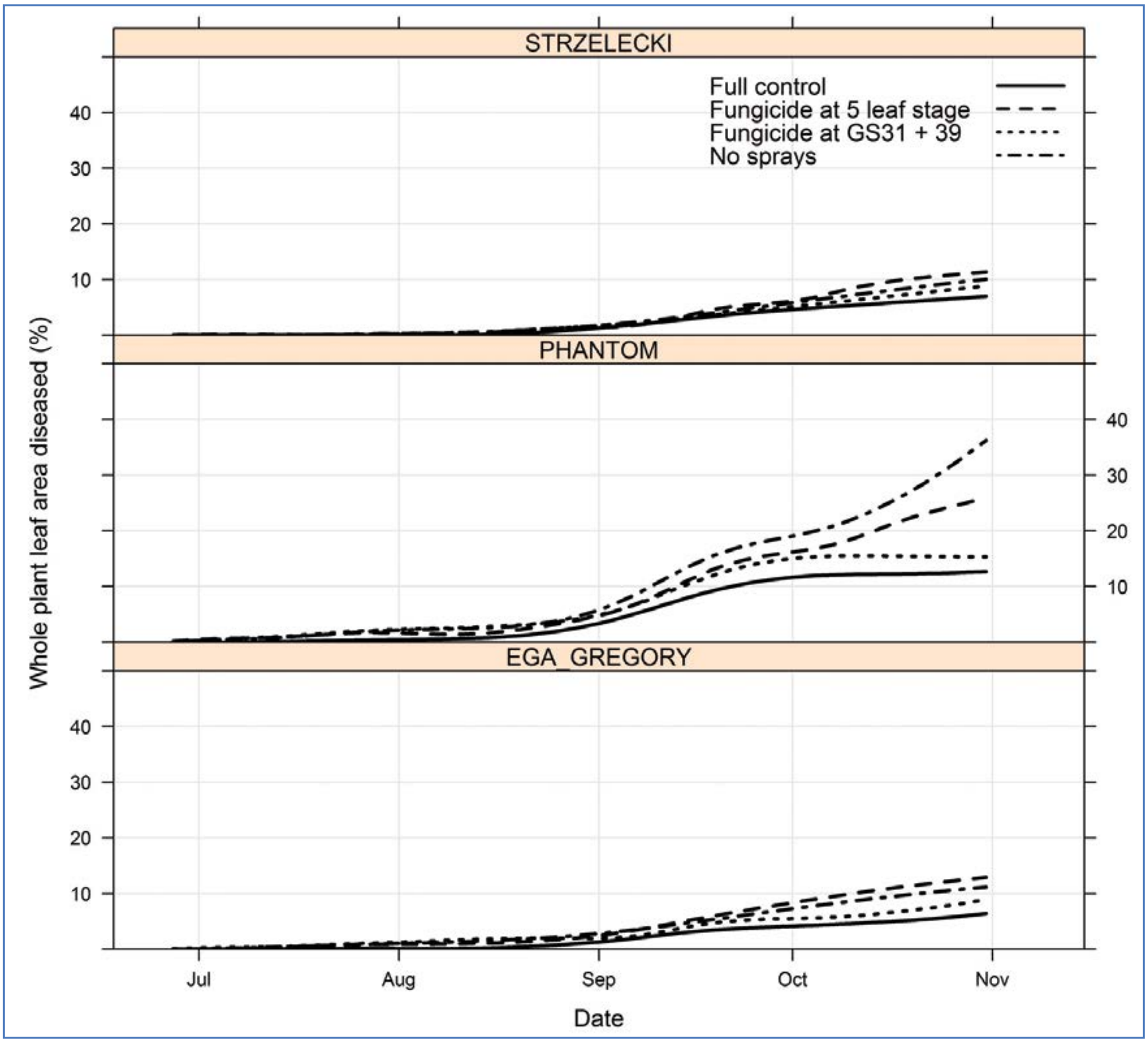

Figure 1: Disease progress in the irrigated Yellow leaf spot experiment Wagga Wagga 2014.

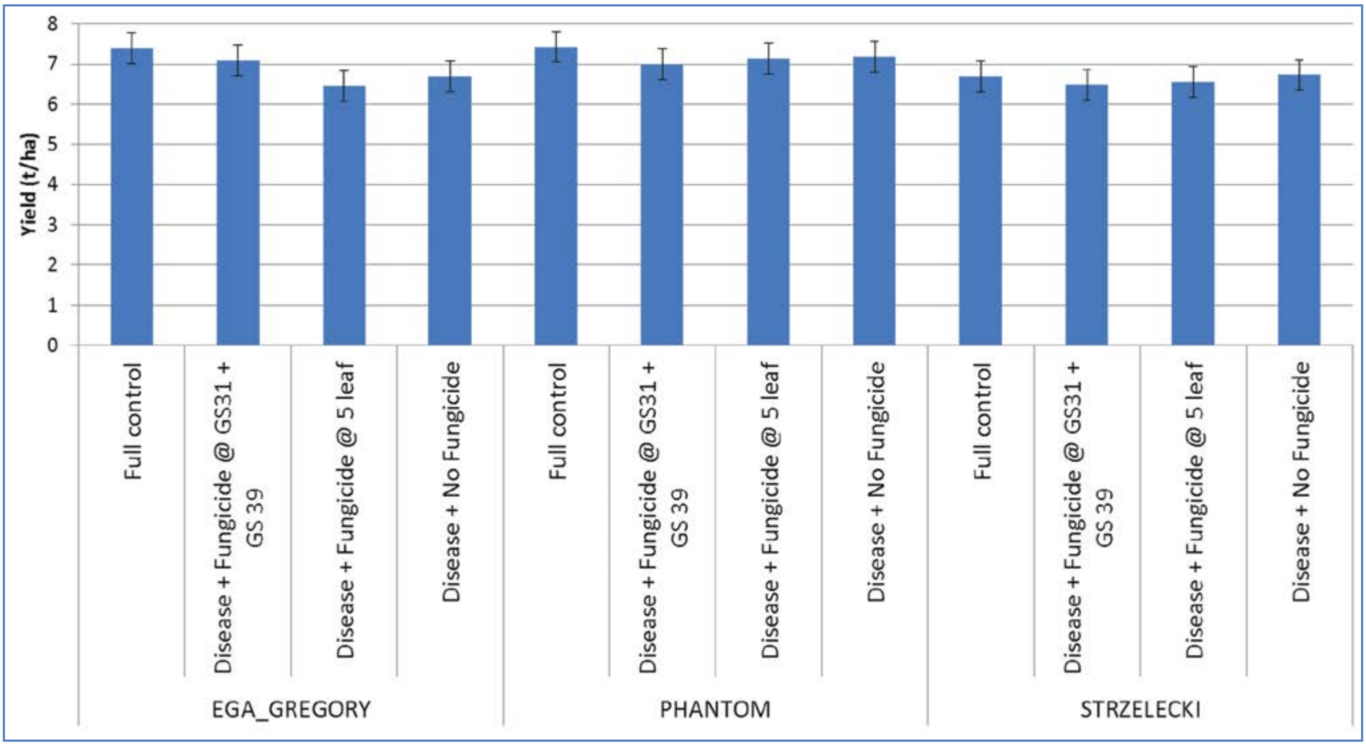

Figure 2: Irrigated yellow leaf spot yield experiment Wagga Wagga 2014. Error bars show LSD at 5%= 0.38 t/ha.

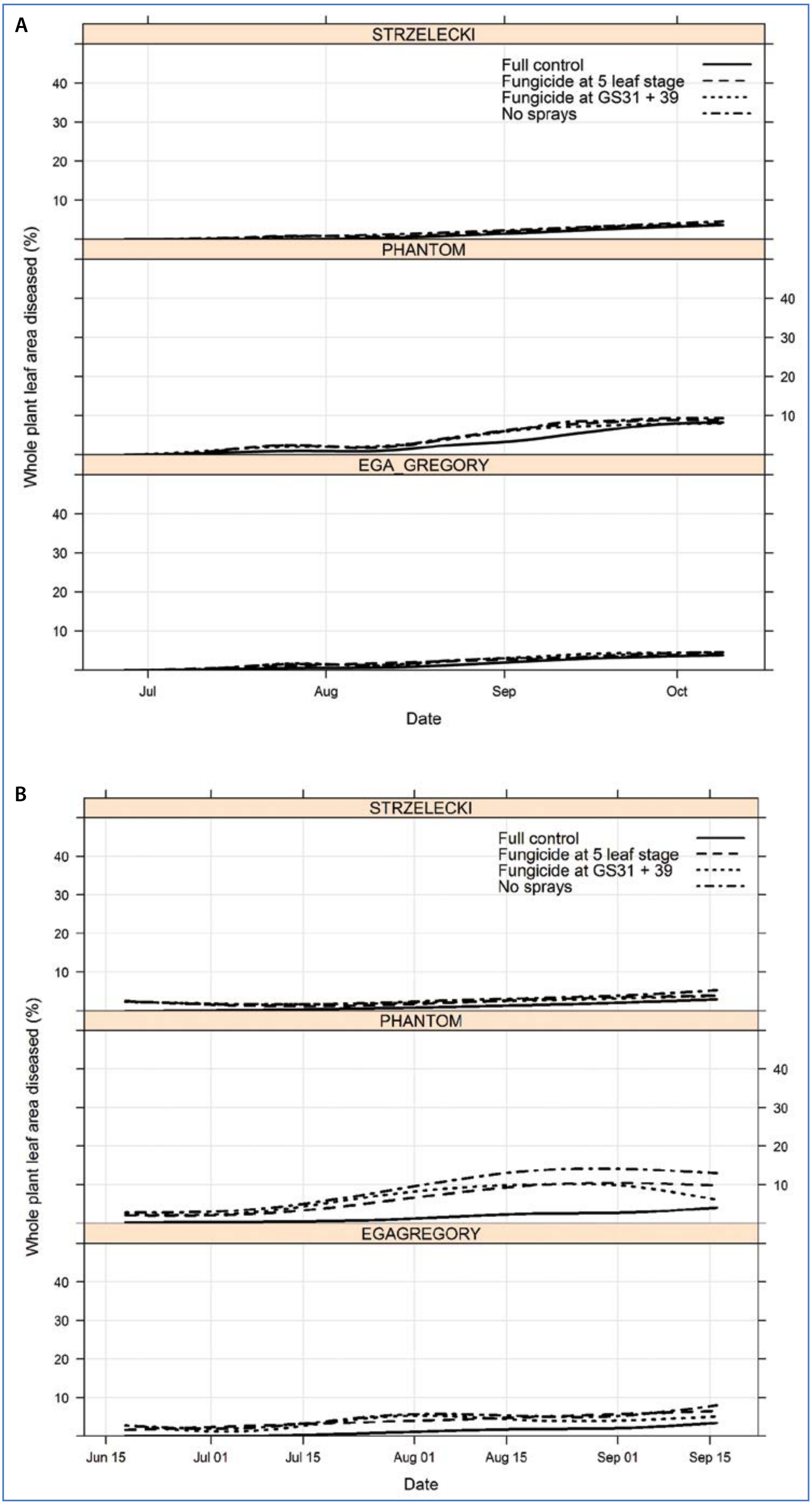

Figure 3: Disease progress in the dryland yellow leaf spot experiment Wagga Wagga (A) and Cowra (B) 2014.

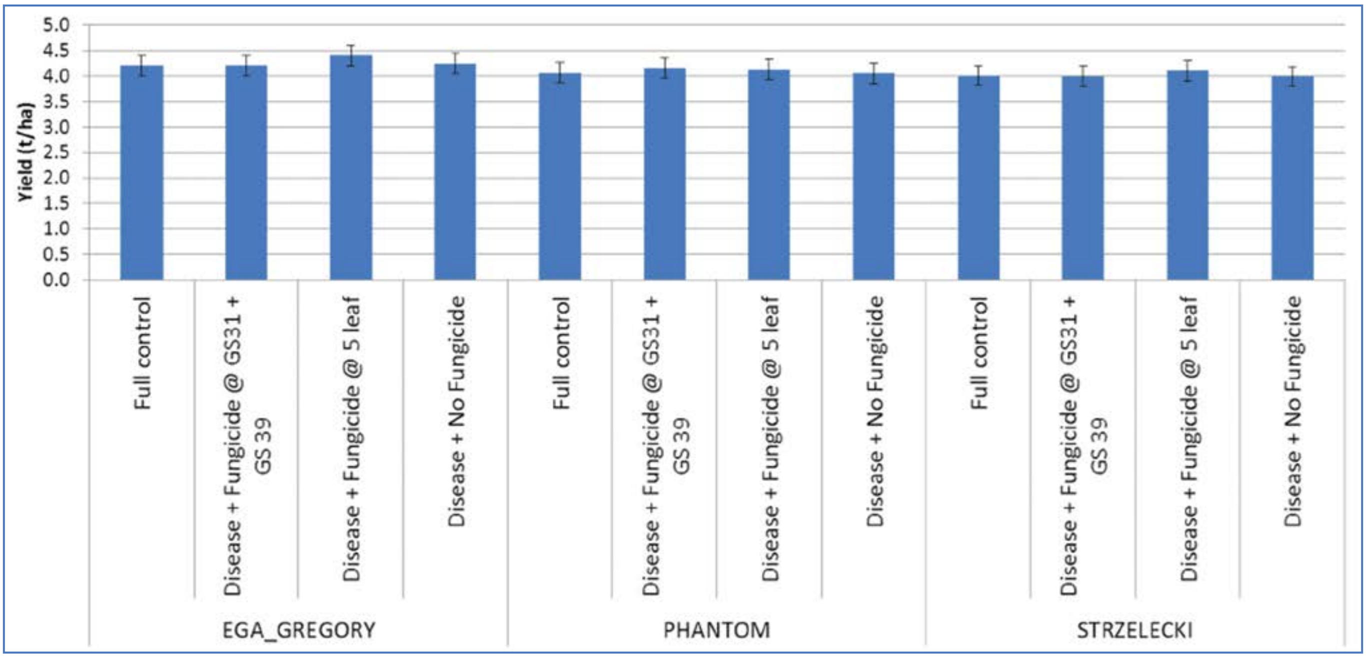

Figure 4: Yield response to fungicide treatments in the dryland yellow leaf spot yield experiment, Wagga Wagga 2014. Error bas show LSD at 5%= 0.2 t/ha.

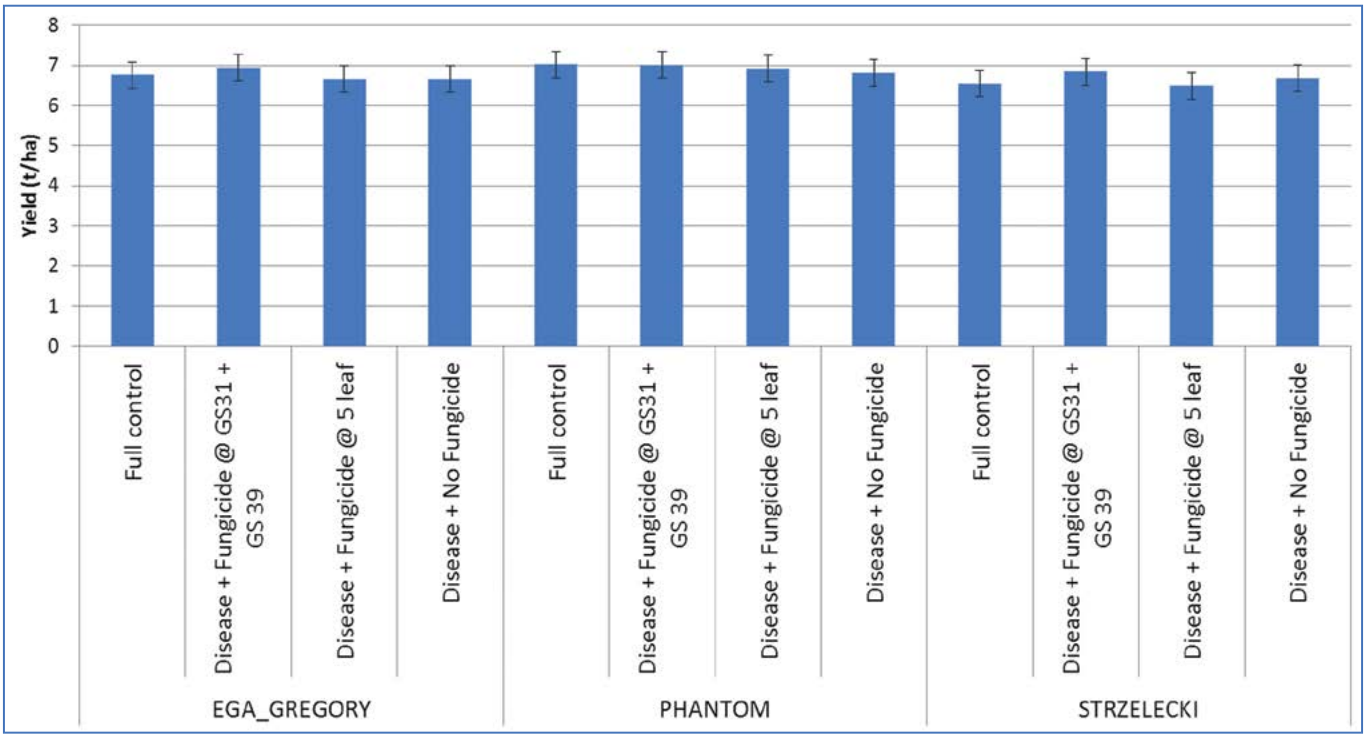

Figure 5: Yield response to fungicide treatments in the dryland yellow leaf spot yield experiment, Cowra 2014. Error bas show LSD at 5%= 0.33 t/ha.

Yield

Grain yield loss due to treatment effects were only observed in the irrigated experiment at Wagga Wagga. There was an anomaly in the results in that the SVS variety Phantom did not produce different yields across the treatments despite having the highest level of disease. This is likely due to the late onset of disease and faster maturity of this variety allowing it to escape the impact of disease in this experiment. The slower maturing variety EGA_Gregory did suffer significant yield loss despite having lower levels of disease development. The highest yielding treatments were the full control and GS31+39 application treatments. The MS variety Strzelecki showed no difference between treatments. The two dryland trials at Wagga and Cowra did not show significant treatment effects.

Summary

These trials confirm the susceptibility of Phantom to yellow leaf spot relative to EGA_Gregory and Strzelecki. Low levels of disease can result in significant yield losses in higher yielding situations, as we observed in the irrigated experiment with the variety EGA_Gregory. However timing of the infection plays an important role in determining if there will be an effect on yield. Complete control of YLS with fungicides was not achieved in the susceptible varieties even with regular applications throughout the growing season.

Note: This is an industry summary provided pre-publication. Further information and analysis will be published in due course.

Acknowledgements

Improving Grower Surveillance, Management, Epidemiology Knowledge and Tools to Manage Crop Disease in southern NSW (DAN00177, 2013–18) is jointly funded by GRDC and NSW DPI and aims to reduce the impact of crop diseases.

All technical components of conducting these experiments were carried out by Mr Tony Goldthorpe and Mr Michael McCaig.

Effect of nitrogen rate and seeding rate on yield of barley—Gerogery 2014

Rohan Brill and Karl Moore NSW DPI, Wagga Wagga

Introduction

This experiment was designed to assess the effect of nitrogen (N) application and seeding rate on grain yield of eight barley varieties in a medium to high rainfall zone at Gerogery in southern NSW.

Site details

Sowing date	21 May 2014
Soil type	Clay loam, pH_{Ca} 6.8
Previous crop	Field peas 2013
Rainfall	316 mm April–October plus 170 mm December–March
Fertiliser	100 kg/ha MAP at sowing
Available N	188 kg/ha (0–60 cm)

Treatments

Varieties	Buloke, Commander, Compass, Flinders, GrangeR, La Trobe, Oxford, Westminster
N rates	0, 30 and 90 kg/ha pre/drilled on 21 May
Seeding rates	75, 150 and 300 seeds/m^2

Key findings

- Compass was significantly higher yielding than all other varieties in this experiment.
- Increasing seeding rate from 75 to 150 seeds/m^2 and further to 300 seeds/m^2 increased grain yield of all varieties.
- There was no effect of nitrogen (N) application on grain yield in this experiment.

Results

There were significant lodging interactions between variety choice, N rate and seeding rate. Only a small amount of lodging was observed at low N and low seeding rates. As seeding rate and N rate increased so did lodging of the varieties Buloke, Commander and Compass. At the highest N rate and seeding rate, these varieties all had similar lodging scores (approximately 40–50% of plants within the plot lodged) however there was no lodging observed in any other varieties.

Grain yield was unaffected by N rate due to the high level of available nitrogen at sowing from previous paddock history. However grain yield of all varieties was positively affected by increasing seeding rate from 75 to 150 seeds/m^2 (0.4 t/ha yield advantage) and further by increasing seeding rate from 150 to 300 seeds/m^2 (0.2 t/ha yield advantage).

Compass was the highest yielding variety in this experiment (*Figure 1*), significantly higher yielding than all other varieties. La Trobe was the lowest yielding variety in this experiment. There were no interactions between variety choice and seeding rate or N rate.

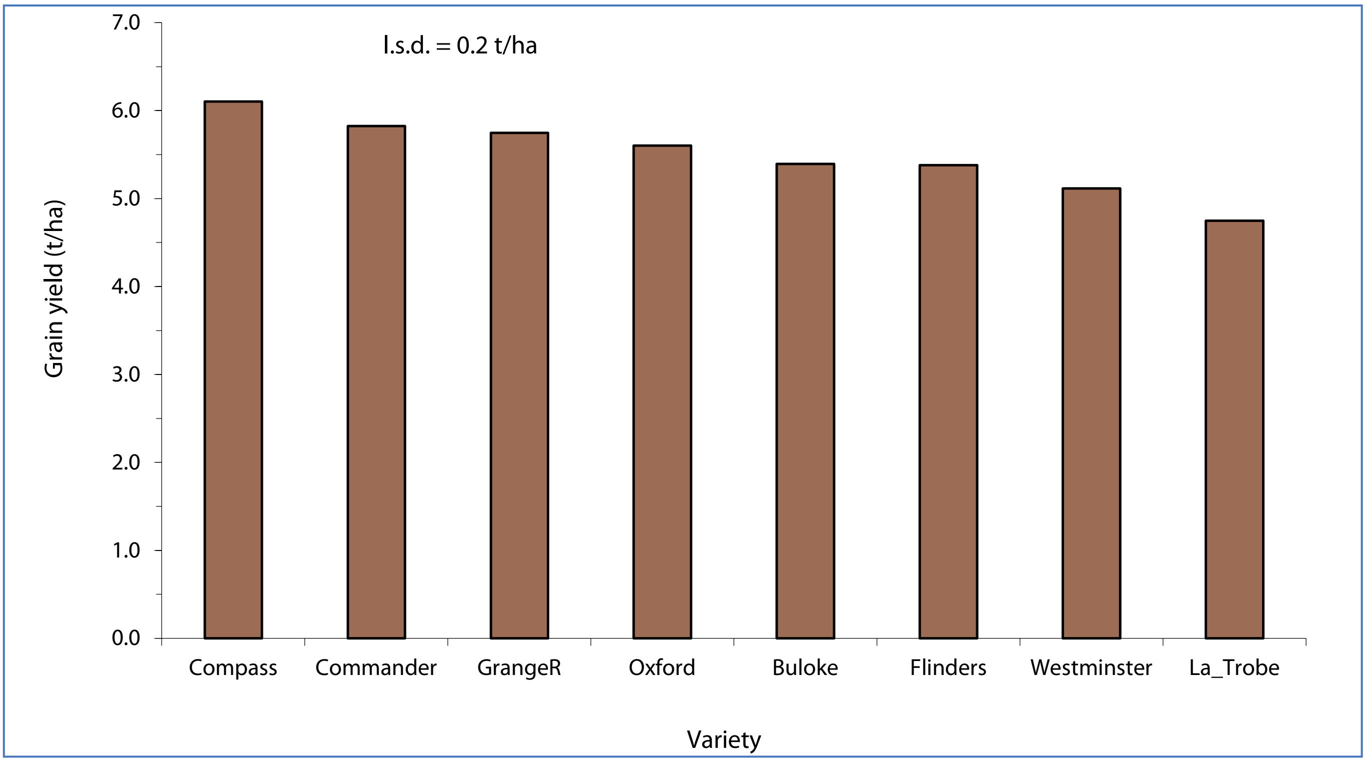

Figure 1: Grain yield of eight barley varieties averaged across three N rates and three seeding rates at Gerogery in 2014.

Summary

This experiment in a medium to high rainfall zone highlighted the difference in varietal performance in different environments. La Trobe performs well in low-medium rainfall environments (refer to the next paper in this report 'Effect of sowing date on phenology and grain yield of barley—Matong 2014') but had relatively low yield in the high rainfall environment. Varieties such as GrangeR and Oxford had high yield in this higher rainfall environment but generally suffer a yield penalty compared to varieties like La Trobe in lower rainfall environments. Compass has achieved good yields across a range of environments; however lodging could be an issue for harvest management in high rainfall zones (*Figure 2*).

There was a clear benefit from increasing seeding rate in this experiment, especially from 75 to 150 seeds/m². This higher seeding rate will also increase competition with weeds. The increase in grain yield from increasing seeding rate may be partially offset by grain quality effects such as smaller grain size, with analysis of the samples yet to be completed.

Figure 2: Lodging in Compass with high N rate and high plant population (left) compared with Oxford sown with a low plant population and low N rate (right).
Photo: R Brill.

Acknowledgements

This experiment was part of *Management of barley and barley cultivars for the southern region* project (DAN00173, 2013–2018), jointly funded by GRDC and NSW DPI.

Thanks to the Moll family 'Elderslie' Gerogery for their cooperation with this experiment. Thanks also to the Wagga Wagga Crop Evaluation Unit for conducting this experiment and Technical staff involved; Phil Armstrong, Warren Bartlett, Greg McMahon, Russell Pumpa and Sharni Hands.

Effect of sowing date on phenology and grain yield of barley—Matong 2014

Rohan Brill and Karl Moore NSW DPI, Wagga Wagga

Key findings

- Early sowing (23 April) reduced yield of most barley varieties in this experiment, likely due to frost events in early to mid-August.
- In this experiment, there was a relatively narrow range in the phenology of barley varieties, with only 17 days difference in flowering date between the quickest variety Hindmarsh, and the slowest variety Navigator.
- Hindmarsh and La Trobe sown 13 May were the highest yielding treatments in this experiment.

Introduction

This experiment was designed to assess the effect of early, mid and late sowing dates on the phenology and grain yield of several newer barley varieties in comparison with traditionally grown varieties in southern NSW.

Site details

Soil type	Red clay loam pH_{Ca} (0–10 cm) 4.5 pH_{Ca} (10–30 cm) 5.7
Previous crop	Wheat (2013 and 2012), stubble burnt prior to sowing
Rainfall	240 mm April–October + 100 mm December 2013–March 2014
Fertiliser	100 kg/ha MAP at sowing + 100 L/ha UAN 29 May

Treatments:

Sowing dates	23 April 13 May 11 June	
Varieties	Bass Buloke Commander Compass Fathom Flinders Gairdner GrangeR Hindmarsh	La Trobe Navigator Schooner Scope Skipper SY Rattler Urambie Westminster Wimmera.

Results

Sowing quick maturing varieties, such as Hindmarsh and La Trobe, on 23 April resulted in flowering in late August (*Table 1*). These early flowering varieties had lower grain yield from the 23 April sowing compared to the 13 May sowing.

Compass and Urambie achieved similar grain yield from the 23 April sowing as the 13 May sowing despite Compass flowering in early September from the earlier sowing. Urambie is considered a 'winter' variety; however it was generally faster to flower than Navigator and only slightly slower to flower than Gairdner.

La Trobe and Hindmarsh were the highest yielding varieties from the 13 May sowing date, with these treatments achieving the highest yields of all treatments in this experiment. Where sowing of Hindmarsh was delayed from the 13 May to 11 June, the average yield penalty was 53 kg/ha per day.

Table 1: Grain yield of 18 barley varieties sown at three sowing dates at Matong in 2014.

Variety	Grain yield (t/ha)		
	23 Apr	13 May	11 Jun
Bass	3.0	3.7	1.9
Buloke	3.2	3.5	2.1
Commander	3.6	4.2	2.5
Compass	4.2	4.2	3.0
Fathom	3.4	4.3	1.8
Flinders	3.1	3.8	1.7
Gairdner	3.1	3.6	1.7
GrangeR	3.6	3.6	1.7
Hindmarsh	3.6	4.5	3.0
La Trobe	3.9	4.6	2.9
Navigator	3.2	3.6	1.7
Schooner	2.8	3.1	1.9
Scope	3.3	3.5	3.0
Skipper	3.6	4.3	2.5
SY Rattler	2.8	3.9	2.2
Urambie	4.1	4.1	1.7
Westminster	3.4	3.2	1.8
Wimmera	3.4	3.9	1.8
Mean of TOS	3.4	3.9	2.2
l.s.d. (p=0.05)	0.3		

There was a strong (R^2=0.68) relationship between flowering date and grain yield (*Figure 1*). Highest yields were achieved where flowering occurred around mid-September, with rapid yield loss occurring as flowering was delayed beyond this date.

Frost was partly responsible for the lower grain yield of some varieties from the 23 April sowing date compared with the 13 May sowing date (*Table 2*). Hindmarsh, Flinders and Fathom all had significantly lower yield from the early sowing and also had greater levels of frost induced sterility (FIS). These FIS assessments were conducted at maturity and there may have been further yield loss from stem frost damage as the most severely frosted stems did not survive to maturity.

Summary

The experiment highlights the need to match sowing date to varietal development in order for flowering to occur in its optimum window. Early flowering exposes crops to frosts and later flowering can expose crops to heat and drought stress. The negative effects of frost on barley highlights just how severe the frost events of 2014 were as barley is generally considered a relatively frost-tolerant crop.

Barley has traditionally been the crop that has been sown late in the sowing program. This experiment quantified the yield loss that occurs in barley as a result of late sowing, with a yield decline of 53 kg/ha per day where sowing was delayed from 13 May to 11 June. At a 2014 feed barley price of $235/tonne this represents a gross income loss of $12.45/ha per day of delayed sowing.

Hindmarsh (and the newer variety La Trobe) had the highest yield in this experiment, reflecting their consistent performance in commercial paddocks over several seasons in the Riverina.

Table 2: Frost induced sterility of five barley varieties sown at three sowing dates at Matong in 2014.

Variety	Frost induced sterility (%)		
	23 Apr	13 May	11 Jun
Compass	8	5	2
Fathom	10	4	5
Flinders	16	6	5
La Trobe	17	7	5
Urambie	8	6	3
l.s.d. (p=0.05)	3.3		

Acknowledgements

This experiment was part of the *Management of barley and barley cultivars for the southern region* project (DAN00173, 2013–2018), jointly funded by GRDC and NSW DPI.

Thanks to the Hatty family – Stephen, Michelle and Rodney at 'Yarrawong' Matong for their cooperation with this experiment. Thanks also to Technical Assistants involved in this experiment, Warren Bartlett, Greg McMahon, Russell Pumpa and Sharni Hands.

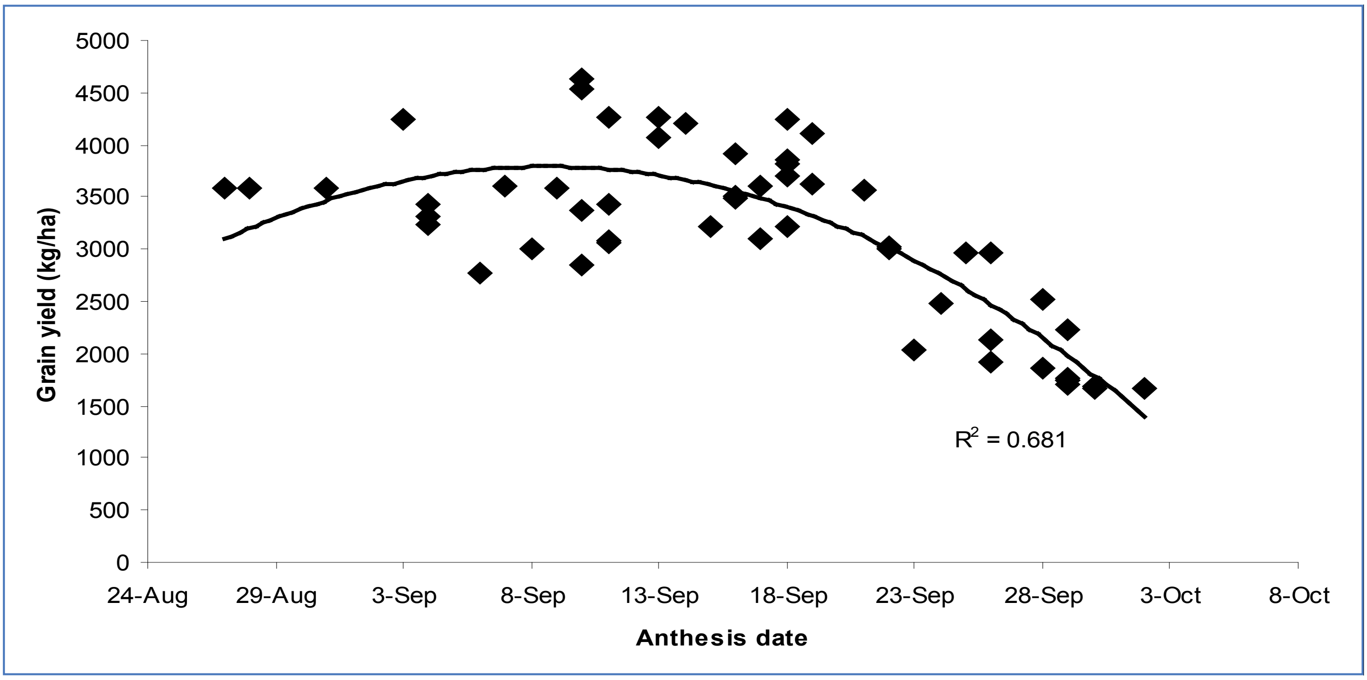

Figure 1: Effect of anthesis date on grain yield of 18 barley varieties sown at three dates at Matong in 2014.

Evaluation of new and potential malt barley varieties—Parkes 2013

Rick Graham and Dr Neroli Graham NSW DPI, Tamworth, Nick Moody and Ian Menz NSW DPI, Condobolin

Key findings

- Averaged across all treatments (N rate and population) Compass, Commander and La Trobe were the highest yielding varieties.
- Compass and Commander achieved significantly lower Grain Protein Concentration (GPC) than the other varieties evaluated.
- Initial findings indicate that Compass which is closely related to Commander performs similar to Commander in terms of grain quality parameters.
- Compass and La Trobe were the best performing potential new malt varieties.

Introduction

Since 2012 nine new malting barley varieties have been accredited by Barley Australia (www.barleyaustralia.com.au). Malting accreditation however, does not guarantee varietal uptake, market demand or price premiums.

When making a decision to grow a new malting variety, growers need to consider both agronomic merit and market potential. Although market acceptance drives the successful commercialisation of a variety, poor agronomic performance limits its likely adoption and long-term viability. Clearly, the ability of a variety to maintain yield potential and still achieve malting grade specifications will impact on varietal uptake and market development. The question facing growers is: which of these new or potential malting varieties should I grow?

The aim of this experiment was to evaluate yield and grain quality responses of new varieties likely to be grown nationally under a range of agronomic input systems.

Site details

Location	Northparkes Mine, Goonumbla, NSW, 2870
Co-operator	Geoff McCallum, Farm Manager, Northparkes Mine
Soil type	red brown clay loam (Red Chromosol)
Nitrogen	112 kg/ha (0–60 cm)
Phosphorus	64 mg/kg (0–10 cm)
Previous crop	canola
Sowing date	31 May 2013
Row Spacing	30 cm
In-crop rainfall	320 mm
Harvest date	20 November 2013
Fertiliser	100 kg/ha Grain Legume Starter (N: 5.1%, P: 15.1%, S: 6.0%)

Treatments

8 barley varieties	Bass, Buloke, Commander, Compass, GrangeR, La Trobe, Skipper, Wimmera
3 nitrogen rates	0, 30 and 90 kg N/ha applied as urea (46% N) top dressed post-sowing, preceding a rain event at the two-leaf stage on June 18
3 seeding rates	Targeting 75, 150 and 300 plants/m^2

The varieties selected included two widely grown malt accredited varieties—Buloke and Commander as comparators; recently accredited malting varieties—Bass, GrangeR and Wimmera; and three varieties currently undergoing accreditation—Compass, La Trobe and Skipper. Grain yields were obtained using a small-plot harvester, with sub-samples of harvested grain analysed for physical and chemical parameters using Grain Trade Australia (GTA) receival standards.

Results

Grain yield

There was a curvilinear yield response for N treatments over all varieties, with a significant increase in grain yield for N applications up to 30 kg N/ha with no response at the higher 90 kg N/ha rate (*Figure 1*). The lack of a yield response at the 90 kg/ha N rate could be attributed to the starting soil N of 112 kg/ha (0–60 cm).

Averaged across all treatments (N rate and population) Compass, Commander and La Trobe were the highest yielding varieties, achieving yields of 4.77 t/ha, 4.62 t/ha and 4.59 t/ha respectively (*Figure 2*).

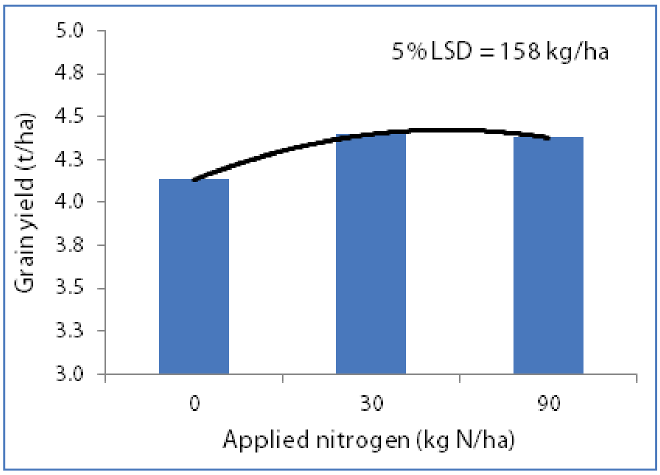

Figure 1: Effect of nitrogen rate on grain yield (t/ha) averaged across all varieties.

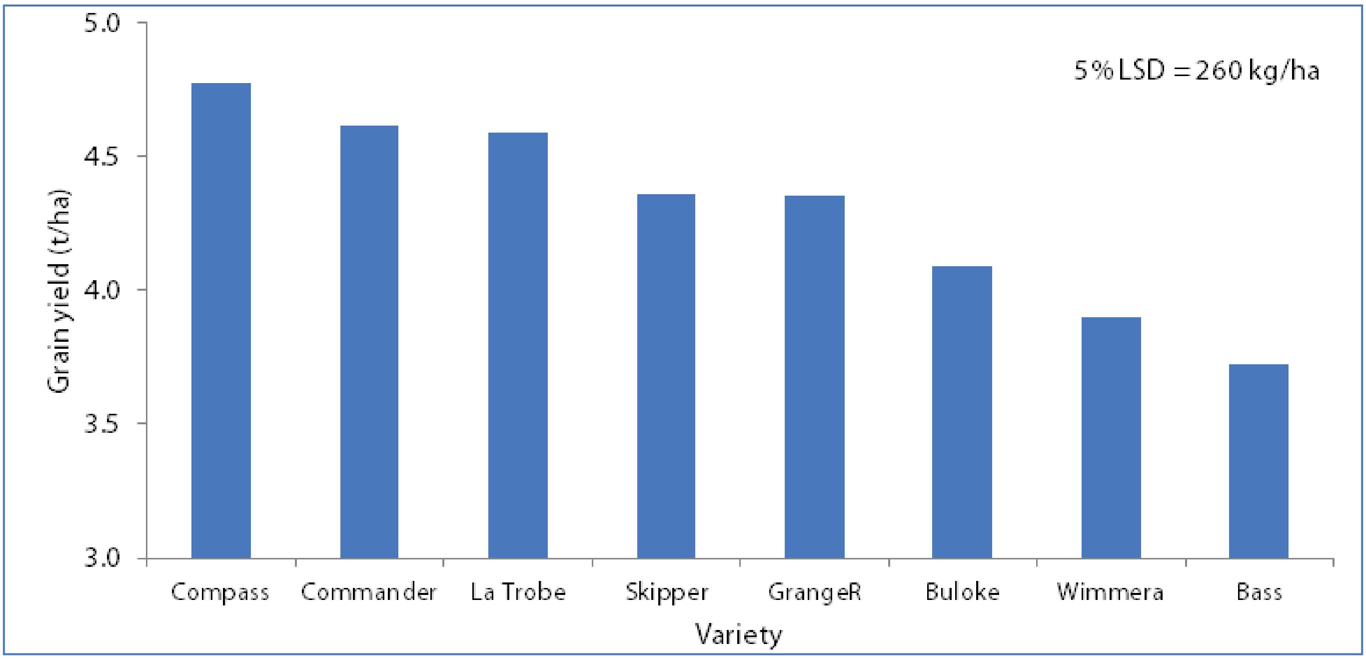

Figure 2: Mean varietal values for grain yield (t/ha) averaged across treatments.

Increasing plant population resulted in an increase in grain yield for all varieties with no variety by seed rate interaction observed. Actual populations achieved were approximately 60, 120 and 220 plants/m² (data not shown). The results showed that there was a yield increase of 0.58 t/ha when plant populations were increased from 60 to 120 plants/m² with a further increase of 0.34 t/ha at 220 plants/m².

Grain quality

To achieve malt grade receival standards, growers need to meet strict industry grain protein concentrations (GPC) of between 9% and 12%, whilst also satisfying physical grain quality receival standards. In contrast to yield, GPC was shown to increase in an almost linear trend with increasing rates of N applied across all varieties (*Figure 3*). Increased plant populations resulted in a decrease in GPC which is consistent with the yield dilution effect (increased yield, decreasing GPC).

Results showed that Compass and Commander achieved significantly lower GPC than the other varieties evaluated, when averaged across all treatments (*Figure 4)*. Looking at the variety responses, Compass and Commander were able to maintain GPC requirements across a range of N rates and plant populations. Although both La Trobe and GrangeR were more GPC responsive in comparison to Commander and Compass, they demonstrated their potential to meet malt specifications. Skipper, although not significantly different in terms of yield to La Trobe and GrangeR, was more GPC responsive in comparison. Wimmera, a longer season variety achieved malting GPC specifications was however, significantly lower yielding (*Figure 2*) and had a lower test weight when compared with all varieties evaluated.

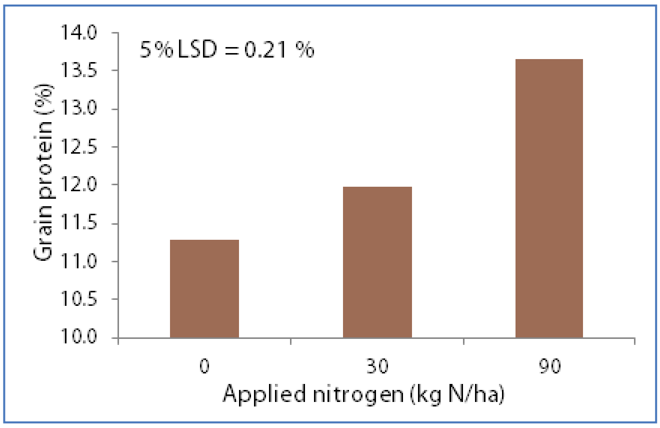

Figure 3: Effect of nitrogen rate on grain protein concentration averaged across all varieties.

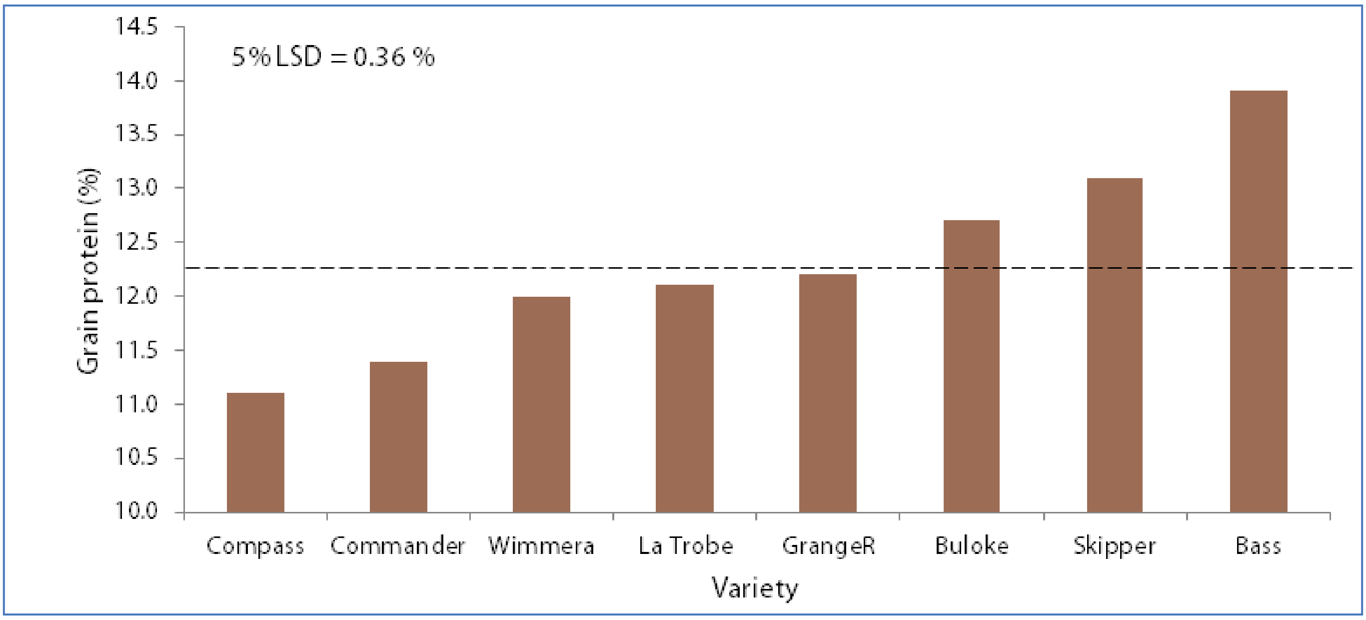

Figure 4: Mean varietal values for grain protein (%) averaged across all treatments.

Summary

Preliminary results from this experiment focusing on new and potential malting barley varieties highlighted the yield and grain quality potential of Compass. On limited data, findings indicate that Compass which is closely related to Commander, a known low grain protein accumulator (Gardner *et al.* 2012), performs comparably in terms of grain quality parameters to Commander. Importantly, Compass was shown to be able to maintain its yield potential while still achieving malting GPC and physical grain quality specifications, across a range of N rates and plant populations.

La Trobe, a sister line to Hindmarsh, and currently undergoing malting accreditation also demonstrated its yield and grain quality potential in this experiment. La Trobe, in a series of trials conducted in 2012 showed its adaptability and potential across a range of environments and treatments (Graham *et al.* 2013).

Importantly, the sensitivity and or responsiveness of varieties to management inputs outlined in these trials will help to develop variety specific management guidelines, increasing the likelihood of variety uptake and the probability of a new variety meeting malt specifications.

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Graham, R., Paynter, B., Fettell, N., Gardner, M., Porker, K., Hills, A., Malik, R., Craig, S., Moody, N. and Graham, N. (2013) '*Yield and quality responses of potential malting barley varieties of national significance*', Proc 16th Australian Barley Technical Symposium, 8–11 Sept. 2013, Melbourne, Victoria.

Acknowledgements

This experiment was part of *Management of barley and barley cultivars for the southern region* project (DAN00173, 2013–2018), jointly funded by GRDC and NSW DPI.

Geoff McCallum and Northparkes Mine are gratefully acknowledged for their assistance and for the provision of the site. Technical assistance provided by Sarah Baxter, Linda Brangwin, Susi Brangwin and Daryl Reardon is also gratefully acknowledged.

Barley scald trials—southern NSW 2014

Dr Andrew Milgate NSW DPI, Wagga Wagga

Introduction

The aim of the experiment was to examine the disease development and yield effects of scald on barley varieties of differing resistance under different inoculum loads and fungicide control levels in southern NSW.

Site details

Wagga Wagga was selected as being representative of the medium rainfall southern NSW winter cropping regions.

Varieties

Four locally relevant varieties with a range of resistance to scald were used, see *Table 2*.

Scald inoculum

Trials were inoculated with stubble collected from the VS variety Yagan southern NSW grown under high disease pressure.

Treatments

Table 1: The six treatments used in scald experiment.

Treatment name	Stubble treatment	Fungicide treatment
Very low + Full control	No stubble applied to plots	Received multiple applications of Bumper® (Propiconazole 250 g/L) at 500 mL/ha
Very low + No fungicide	No stubble applied to plots	Received no fungicide sprays
Low + No fungicide	Stubble 100 kg/ha applied to plots	Received no fungicide sprays
Medium + No fungicide	Stubble 500 kg/ha applied to plots	Received no fungicide sprays
Medium + GS31 Spray	Stubble 500 kg/ha applied to plots	Bumper® (Propiconazole 250 g/L) at 500 mL/ha applied at GS31
High + No fungicide	Stubble 2500 kg/ha applied to plots	Received no fungicide sprays

Table 2: Varieties included in scald trials 2014.

Variety	Scald rating 2014§	Scald rating 2015§
Fathom	MR	MR#
SY Rattler	MS	SVS
Flinders	S	SVS
Yagan	VS	VS

§ As published in the NSW DPI Winter crop variety sowing guide 2014 and 2015.

Key findings

- Scald can cause very high yield losses in southern NSW. Losses recorded in these trials reached 55%.
- Variety choice has a large impact on management and yield. The more resistant varieties provide multifaceted benefits.
- The risk of losses to scald increases rapidly if crops are sown into infected stubble.
- Fungicides are effective but timing of application is critical in high disease pressure situations.

Table 3: Sowing and fungicide application dates 2014.

Location, experiment	Sowing date	Fungicide application dates
Wagga Wagga, Dryland	8 May	31 July (full control every 3 weeks)
Wagga Wagga, §Irrigated	8 May	31 July (full control every 3 weeks)

§ Supplementary spray irrigations applied to promote disease in experiment; timing and rate varied in response to seasonal factors between August and November to ensure conducive disease environment.

Results

Disease severity

Scald severity was very high in the irrigated trials (*Figure 1A*). Significantly different disease progress curves were observed between the varieties and the treatments. Disease development commenced early during July in the more susceptible varieties. The amount of infected stubble placed on plots had little impact on disease development, even for the low rate of 100 kg/ha treatment produced high levels of disease. Where no stubble was applied and infection was caused by spores moving between plots variety differences could be observed. Regular fungicide applications controlled disease in this high pressure situation. A single fungicide application at GS31 did slow disease progress however this was not sufficient to prevent the epidemic from commencing again once the fungicide activity had worn off.

The dryland experiment was affected by the dry spring conditions, in general showing lower levels of disease (*Figure 1B*). However disease did develop to moderate levels particularly in the more susceptible lines. Similar to the irrigated experiment the amount of infected stubble applied showed little difference in causing disease. Infection can progress quickly during spring,

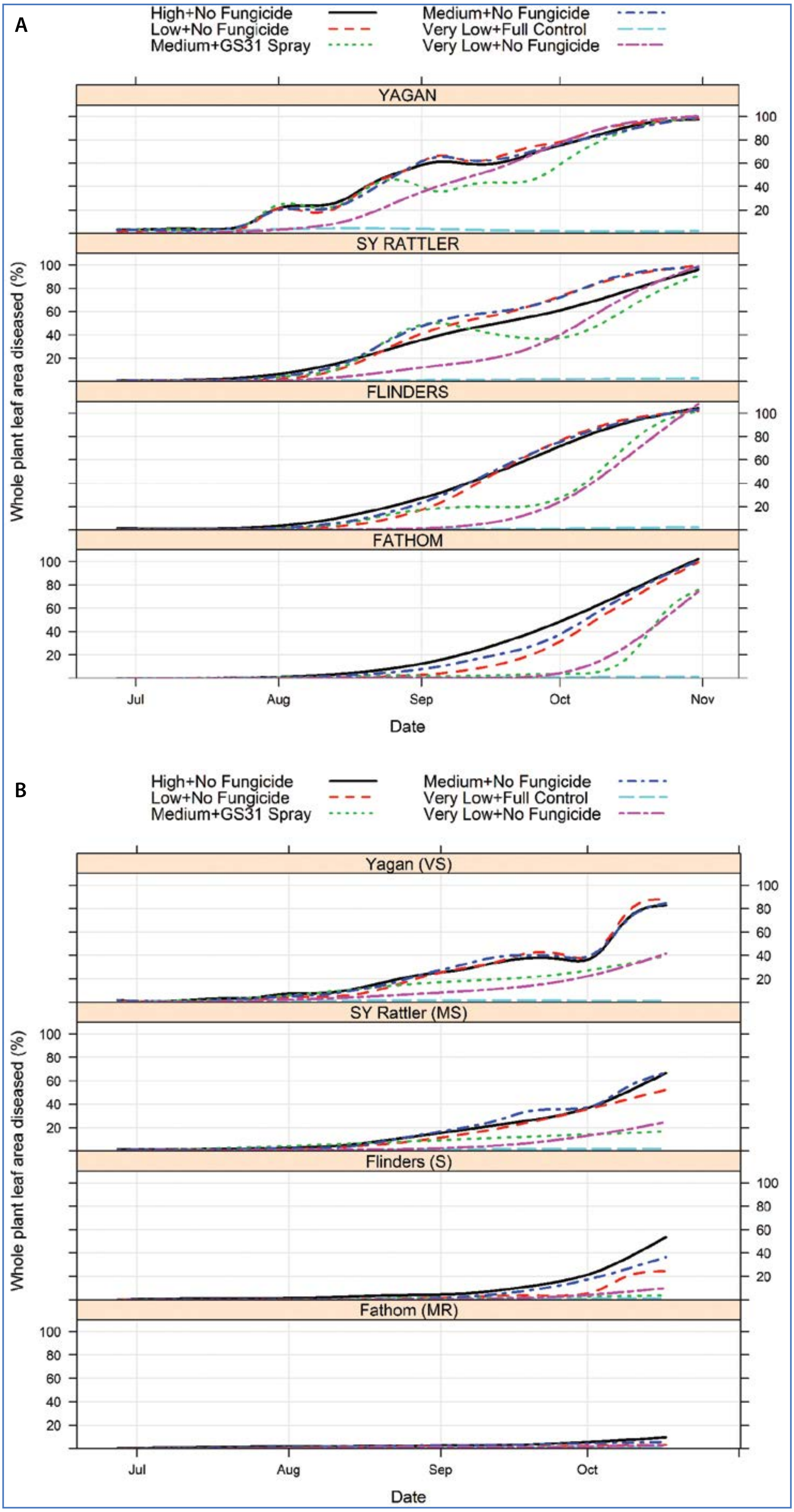

Figure 1A: Disease progress in the irrigated (A) and dryland (B) barley scald Wagga Wagga 2014.

as can be seen in *Figure 1B*. The disease progress of the three more susceptible varieties responded sharply to a rainfall event in spring which created favourable conditions for infection.

Yield

Large yield losses were observed in the irrigated experiment of up to 55% compared to the full control treatment (*Figure 2*). A single application of fungicide gave variable yield benefits between the varieties. For Fathom, the MR variety, a single spray was not significantly different from the full control treatment losing on average 6% of yield. Compared to the other varieties losses with one spray ranged from 15% to 39%. A trend in the impact of starting inoculum was only observed for Fathom.

In the dryland experiment losses were lower but still significant in the more susceptible varieties reflecting the lower level of disease (*Figure 3*). The VS variety Yagan with high level of stubble inoculum still lost 24% of yield compared to the full control. Compared to the more resistant variety Fathom there were no significant treatment effects.

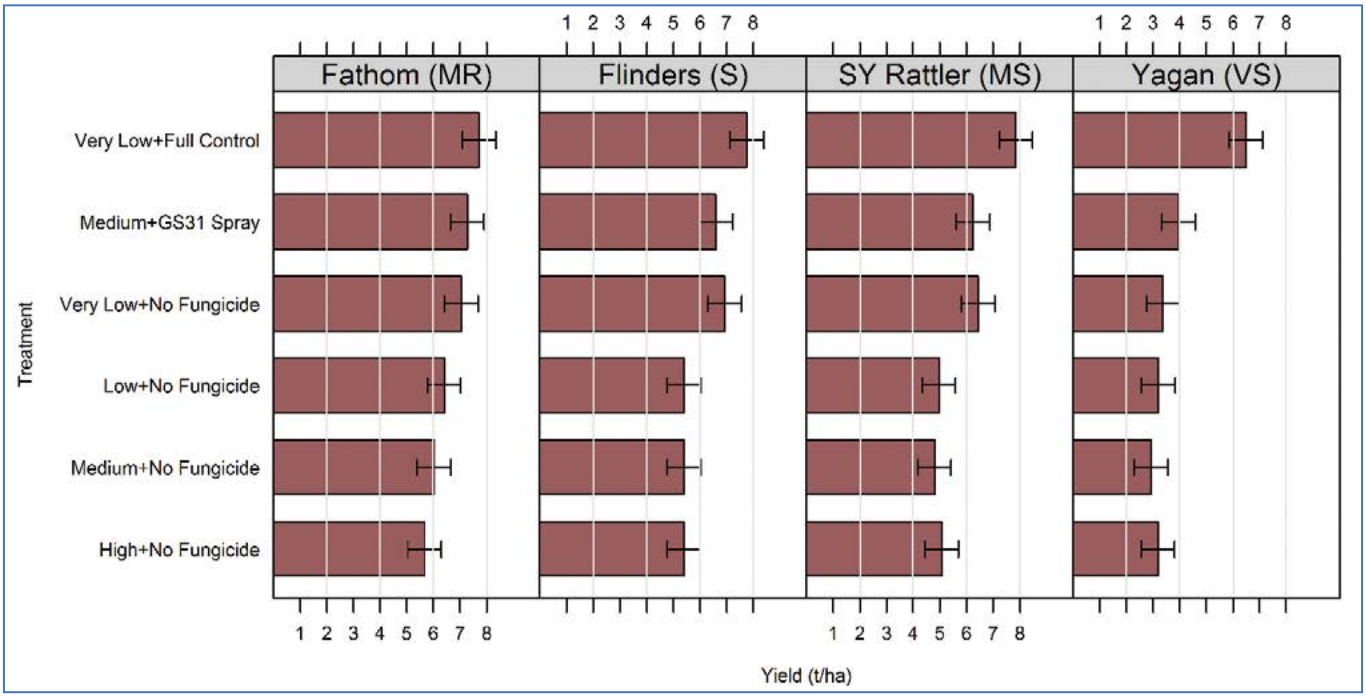

Figure 2: Irrigated barley scald experiment Wagga Wagga 2014. Error bars show LSD at 5%= 0.63 t/ha.

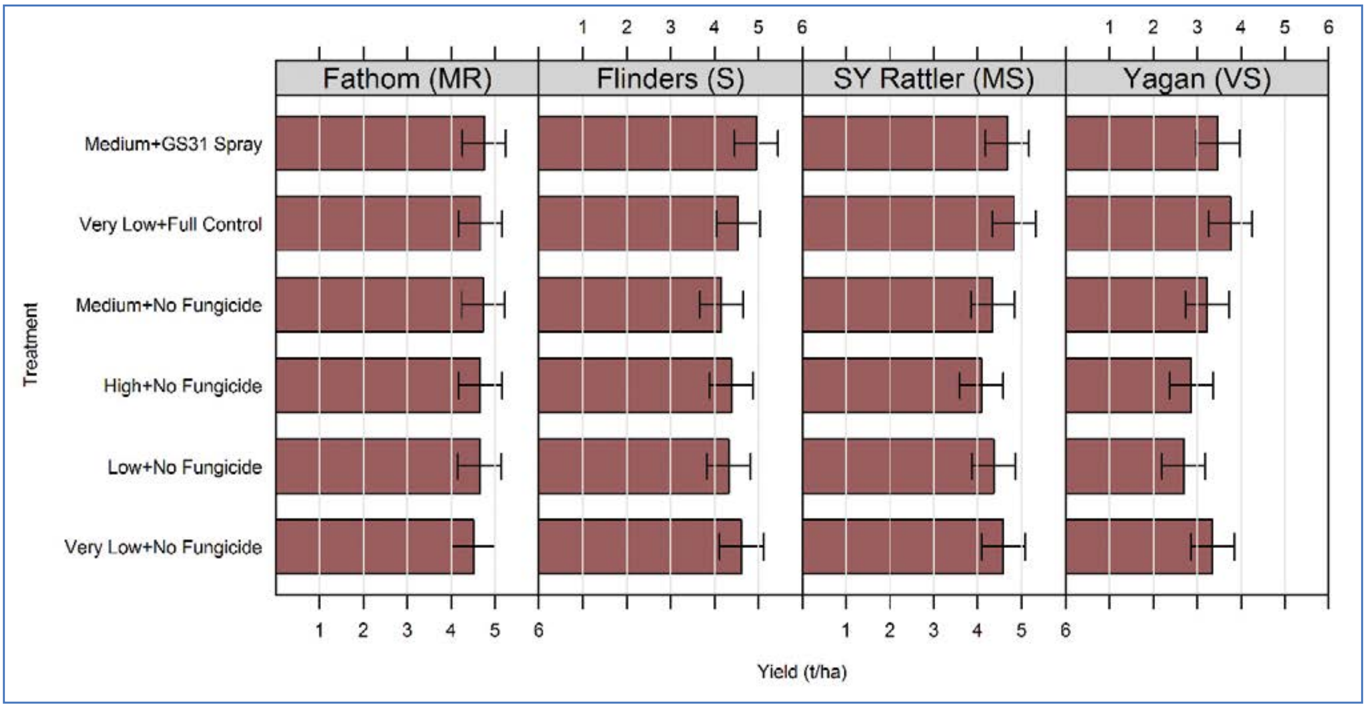

Figure 3: Dryland barley scald experiment Wagga Wagga 2014. Error bars show LSD at 5%= 0.49 t/ha.

Summary

Scald epidemics can start from very low levels of inoculum and rapidly respond to changes in weather conditions. The yield impact on varieties is correlated with their resistant ratings. The benefits of resistant varieties is multifaceted they can cause; reduction in the need for fungicides applications, reduced inoculum and increased yield in the presence of the disease compared to susceptible varieties.

Note: This is an industry summary provided pre-publication. Further information and analysis will be published in due course.

Acknowledgements

Improving grower surveillance, management, epidemiology knowledge and tools to manage crop disease in southern NSW (DAN00177, 2013–18) is jointly funded by GRDC and NSW DPI and aims to reduce the impact of crop diseases. These trials were also supported by the GRDC *National yield loss curves* project.

All technical components of conducting these experiments were carried out by Mr Tony Goldthorpe and Mr Michael McCaig.

Time of sowing soybeans—southern NSW 2013-14

Luke Gaynor and Mark Richards NSW DPI, Wagga Wagga and Alan Boulton NSW DPI, Yanco

Key findings

- The ideal sowing time for soybeans in southern NSW is mid-November to early December.
- Djakal, Bidgee and Snowy are all high yielding varieties under good crop agronomy practices.
- Late December planting still provides good yield opportunities when managed correctly—correct variety selection and achieving adequate plant population.
- Achieving full canopy closure prior to flowering is critical to maximising both biomass and grain yield potential.

Introduction

A soybean experiment was conducted at the Leeton Field Station to test the response of 20 advanced-stage lines and commercial varieties to two times of sowing 29 days apart. The first time of sowing (TOS) was 20 November 2013 followed by the second sown on 19 December 2013. These two times of sowing represent the ideal sowing window (20 November) and later than ideal sowing (19 December) for this region. In southern NSW the sowing window is from mid-November to late December.

The trials discussed are part of the National Soybean Breeding Program funded by GRDC, NSW DPI and CSIRO. The breeding objectives are to produce soybean varieties for human consumption markets that are high yielding, early maturing, with disease tolerance. Recent releases include Bidgee, Snowy and Djakal.

Site details

Location	Leeton Field Station, Yanco NSW
Trial period	summer growing season 2013–14
Soil type	self-mulching medium clay
Previous crop/s	wheat then fallow
Plant available water	pre-watered
Sowing date TOS 1	20 November 2013
Sowing date TOS 2	19 December 2013
Plant population	30 plants/m^2
Inoculation	water injected peat slurry Group H
Irrigation layout	1.83 m (6 ft) raised beds
Row spacing	2 rows/bed (91.5 cm)
Fertiliser	125 kg/ha legume starter
In-crop rainfall	177 mm plus weekly or fortnightly irrigations as required
Insecticides	Abamectin @ 500 mL/ha on 18 December 2013, Lamdacyhalothrin @ 80 mL/ha on 21 March 2014
Harvest date	16 April 2014
Irrigations	approximately 8 ML/ha

Results

The 2013–14 season was a difficult season for growing soybeans. As shown in *Figure 2*, temperatures from January to March were well above long-term averages and the heat units per month [Growing Day Degrees = (Max + Min)/2 minus 5°C, which is the base temperature for when soybean growth stops]. This extreme heat coincided with peak flowering and early pod development.

Subsequently, plants suffered heat stress and yield potential was reduced because plants were exposed to longer periods of extreme heat. Soybeans as an indeterminate plant type normally respond well after heat stress. However, due to the prolonged heat and loss of flowers and podding sites, grain yields of the November sown treatments were affected.

In *Figure 3*, grain yields of the advanced breeding lines can be seen with commercial checks of Djakal, Bidgee, Snowy and Bowyer. Long-term data indicate Djakal has an average yield of 4.1 t/ha at 12% moisture (based on over eight years of replicated data). As shown in this experiment, overall mean yields were reduced by approximately 0.5 t/ha which is likely to be a direct result of the seasonal heat stress.

Several standout breeding lines include N005A-80, P176-2, P176-1, P176-14 and N116C-3. These lines will be evaluated and tested further for potential release.

In *Figure 3*, the dashed lines indicate a significant yield difference from benchmark variety Djakal with a least significant difference (LSD) of 0.366 t/ha. N005A-80 is currently under commercial seed increase and evaluation for commercial release.

In comparison, TOS 2 (19 December 2013) grain yield results are in line with what we would expect for this time of sowing. The crop avoided any early yield setbacks from the January and February heat as the lines would have only commenced flowering by early to mid-February. The bulk of the flowering and pod development was after the peak heat periods.

Similar to the early sown experiment, the breeding lines of N005A-80, P176-2, P176-1, P176-14 and N116C-3 performed better than the other lines.

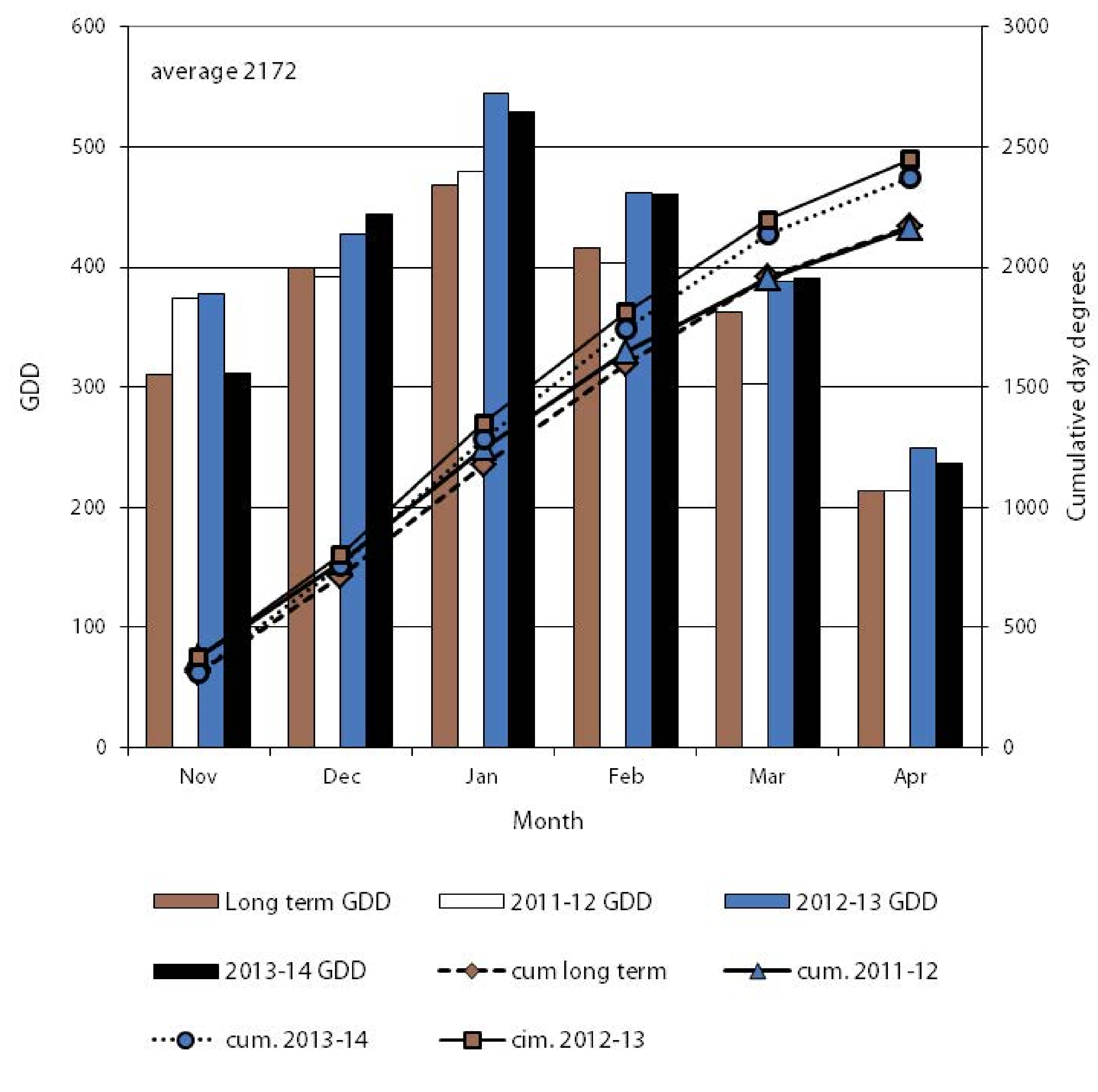

Figure 2: Average 1983–2013 monthly growing day degrees vs 2012–13 vs 2013–14 at Yanco.

Further analysis of seed quality showed that all lines met the minimum requirements of protein content on a dry matter basis. Djakal has the lowest acceptable level of protein to meet human consumption standards.

Further sampling showed large variations in seed quality between November and December sowing. A significant amount of weather damaged seed was observed from TOS 1 due to this experiment maturing earlier and being exposed to 100 mm of rainfall over March and April 2014. Further observations of TOS 1 showed a level of pod shattering, which again resulted in the reduction of grain yields.

Pod shattering is uncommon in southern NSW and occurs more often in tropical agriculture areas. Pod shattering is promoted by continued wetting and drying of mature pods. The harvest of 2014 experienced these conditions with warm days and rainfall totals over 100 mm. Harvesting as soon as possible is recommended to avoid pod shattering especially with early maturing types like Bidgee. Harvesting at a seed moisture of 13% meets industry receival standards.

Summary

Despite low grain yields in 2013–14, long-term trials clearly show that average grain yields are maximised by sowing mid-November to early December in southern NSW. Further south into northern Victoria, sowing should begin earlier, from 1 November until late November.

Grain yields for the late December sowing time were still very good which shows that current varieties can effectively fit into a double-cropping system where a later sowing window is often required.

As shown in *Figure 2* the January and February period for the past two seasons have provided significantly higher growing day degrees compared with the previous two seasons. This has resulted in some genotype by environment interactions not observed in previous years. These results provide a basis to further explore these interactions with current germplasm and identify better adapted varieties.

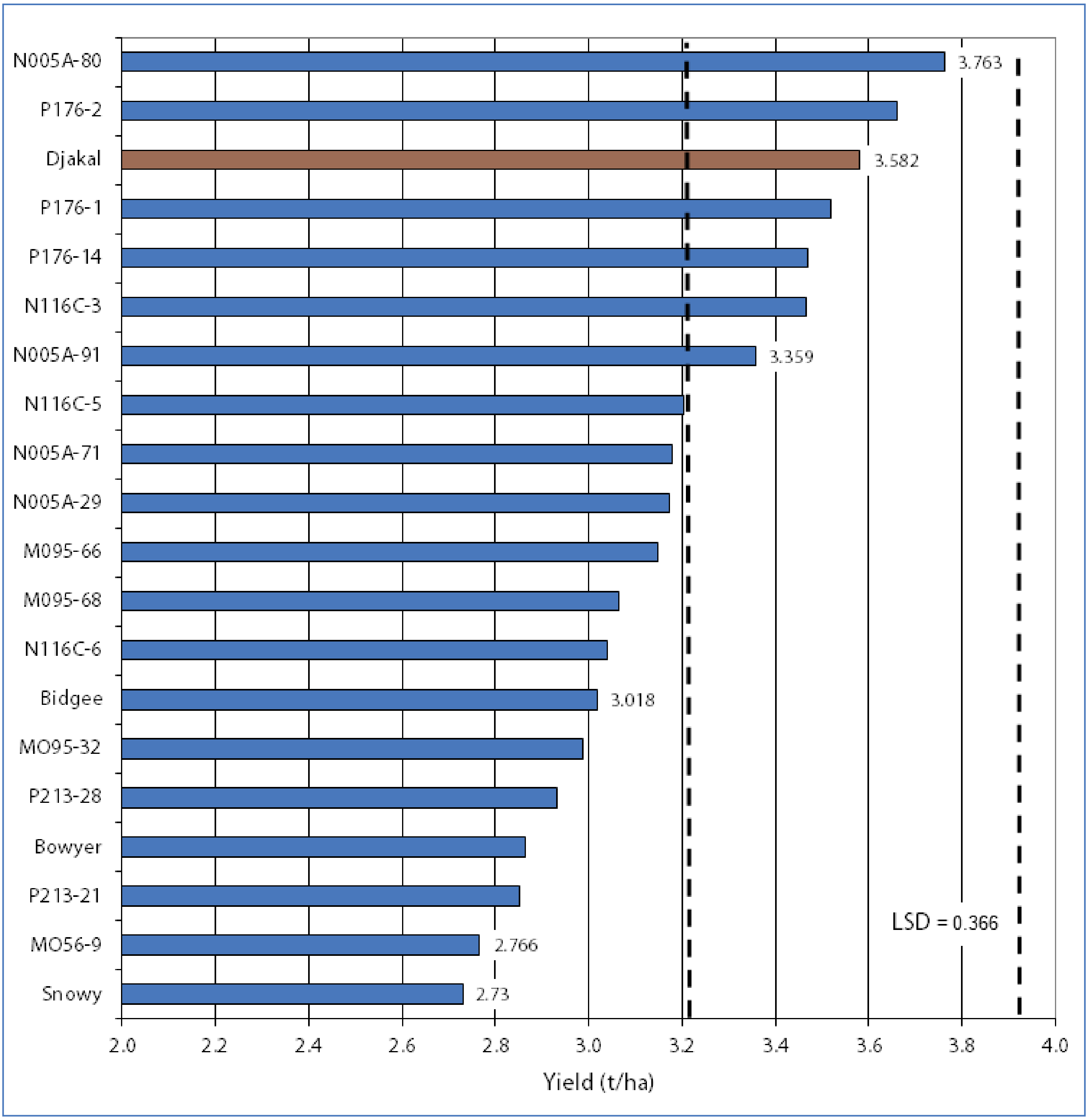

Figure 3: Grain yield of soybean varieties in the core variety trial at Yanco 2013–14, TOS1 sown 20 November 2013.

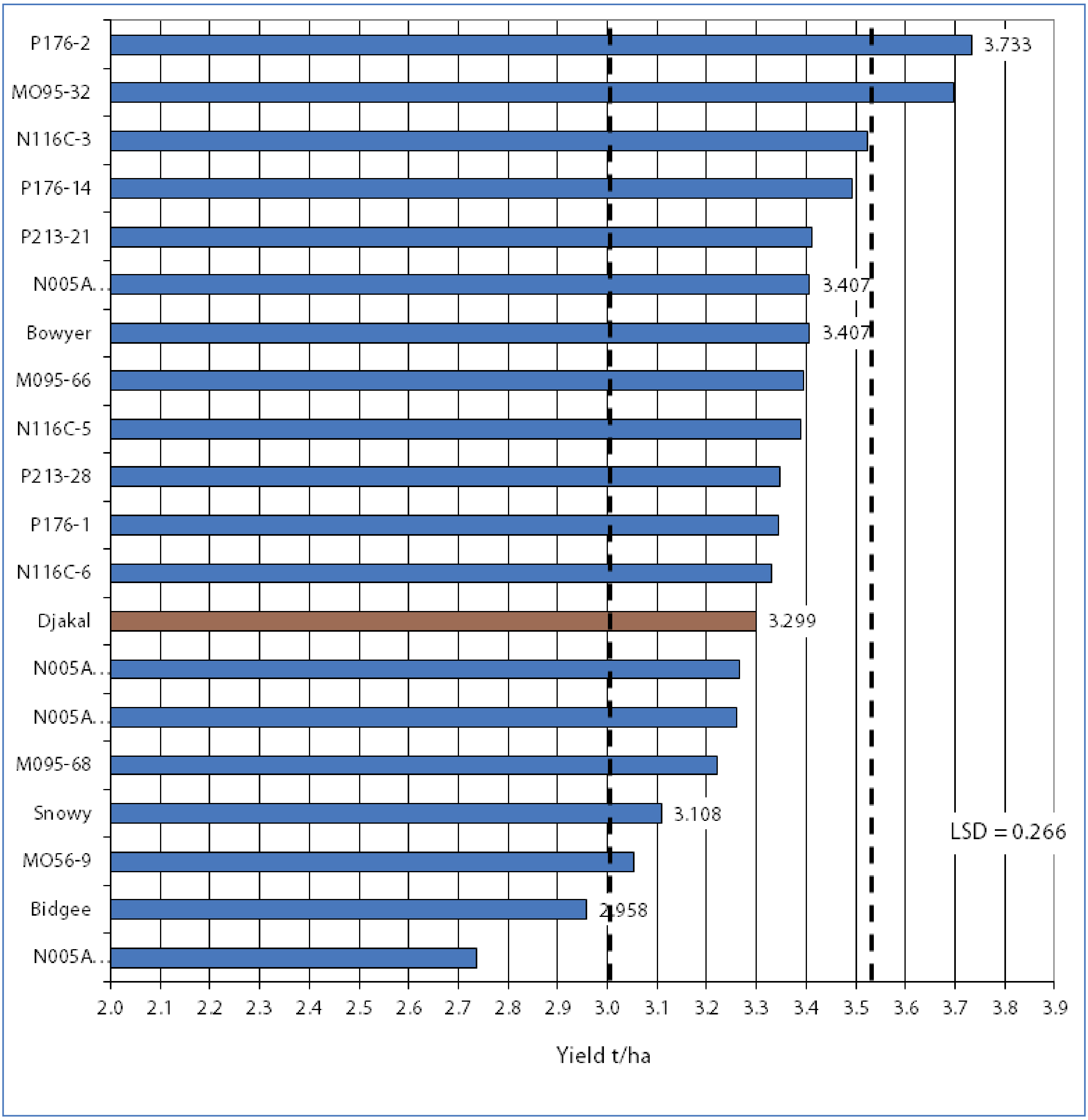

Figure 4: Grain yield of soybean varieties in the core variety trial at Yanco 2013–14, TOS2 sown 19 December 2013.

Acknowledgements

The experiment is part of the *Southern NSW soybean agronomy* project (DAN00192, 2014–2018) jointly funded by GRDC and NSW DPI.

Thank you to John Dando and the NSW DPI farm staff at Yanco for their assistance in managing the site. Also, thank you to Dr Neil Coombes from NSW DPI for undertaking the biometrical tasks associated with this project.

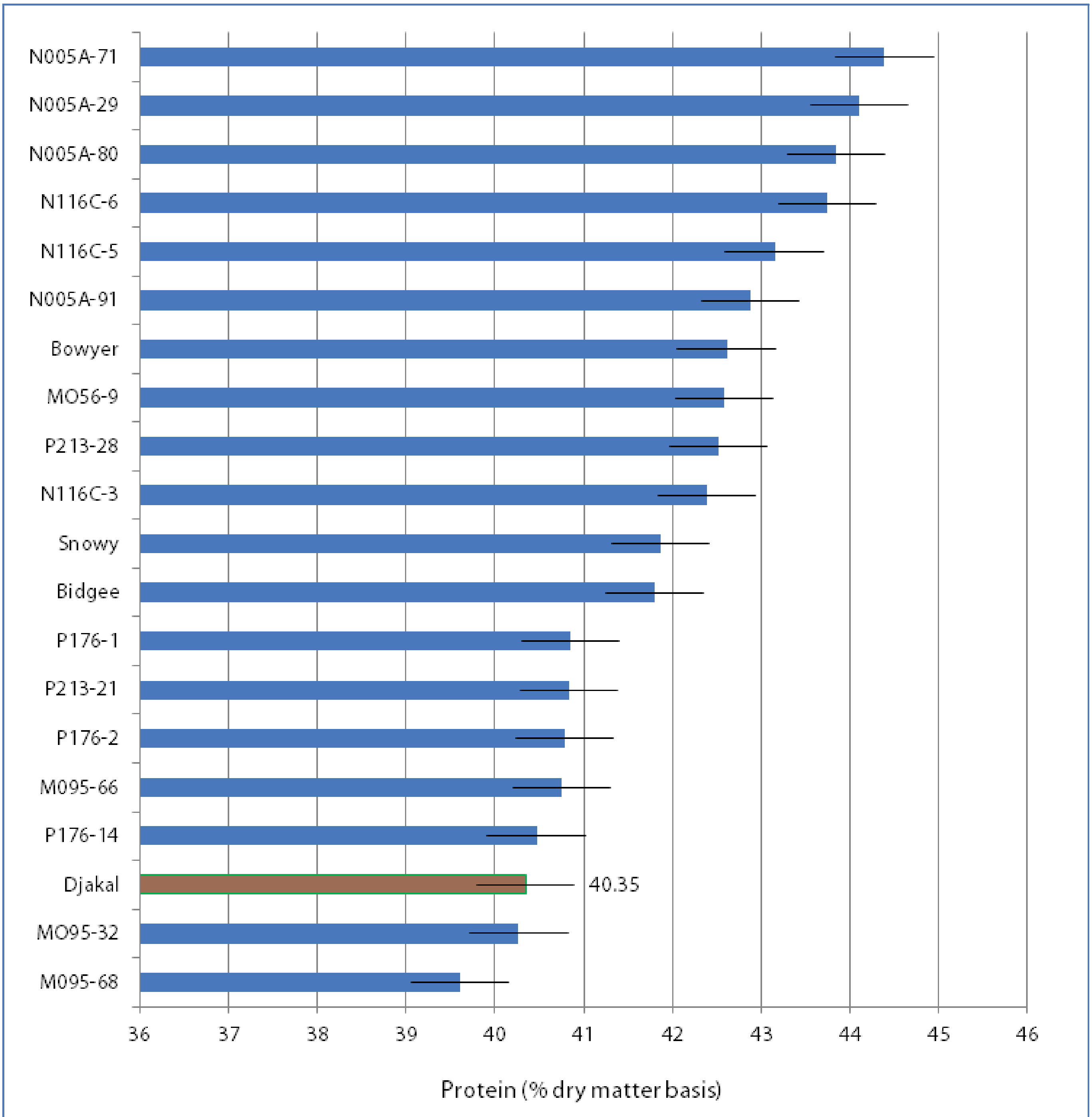

Figure 5: Protein (%, dry matter basis)) of soybeans TOS1 sown 20 November 2013, in the core variety trial at Yanco.

Powdery mildew control in soybeans

**Luke Gaynor NSW DPI, Wagga Wagga, and
Alan Boulton NSW DPI, Yanco**

Key findings

- Fungicide applications achieved excellent control of powdery mildew.
- Overall, fungicide applications this season in the Riverina did not increase grain yields that were statistically significant. A small but non-significant trend was detected with fungicide application.
- Djakal is the only current variety in southern NSW with powdery mildew resistance.

Introduction

Powdery mildew (PM) is a disease in soybeans caused by the fungal pathogen Erisyphe diffusa (Microsphera diffusa syn.). It has been a problematic disease in field-grown soybeans in the USA since the early seventies and is a major production issue in the tropical and semi-tropical soybean growing areas of Australia. It has appeared in the southern temperate region i.e. the Riverina, New South Wales, in the last three years (since 2011–12), and has caused significant infections in susceptible varieties. Powdery mildew thrives in dry (no rainfall), humid conditions and has been a problem in recent seasons in the Murrumbidgee Irrigation Area.

Last season (summer of 2013–14), it was decided to investigate the potential impacts of this disease on yield of the main commercial varieties used in this cropping region, and a new unreleased line (N005A-80) that has shown good yield potential but unfortunately is susceptible to this pathogen. Potential treatment options for this disease were also evaluated.

Site details

Location	Leeton Field Station, Yanco, NSW
Trial period	summer growing season 2013–14
Soil type	self-mulching medium clay
Previous crop/s	wheat then fallow
Plant available water	pre-watered
Sowing date	4 December 2013
Planter	two rows on a 1.83 m bed
Fertiliser	125 kg/ha legume starter
In-crop rainfall	177 mm plus weekly or fortnightly irrigations as required
Insecticides	Abamectin @ 500 mL/ha on 18 December 2013 Lamda-cyhalothrin @ 80 mL/ha on 21 March 2014
Harvest date:	16 April 2014

Treatments

Varieties	Djakal, Snowy, Bidgee, N005A-80
Fungicides (PM control)	Tebuconazole 430 g/l: full rate at full flower Product A: full rate at full flower Product A: split application 50% at full flower, 50% approximately three weeks later Nil
Fungicide applications	Tebuconazole: at full flower applied at 150 mL/ha on 31 January 2014 Product A: at full flower applied at 400 mL/ha + 1% Hasten® on 31 January 2014 Product A: at full flower applied at 200 mL/ha + 1% Hasten® on 31 January 2014 and at 200 mL/ha + 1% Hasten® on 20 February 2014 Control, nil applied

Note: Applied with commercial boom spray equipment at 200 L/ha.

Results

- Powdery mildew had little effect on grain yield. There was no significant yield advantage observed with full disease control using fungicides. Further work is required to test fungicide use across seasons, varieties and sites.
- Product A, when applied as a split application was efficacious against PM.
- The variety Djakal showed its known resistance to PM.
- Tebuconazole has a permit for use (PER14645) in soybeans to control PM.
- Product A is not currently permitted in Australia for use in soybeans. It is also an expensive product which will deter its use in soybeans grown in the southern regions at the moment. However, it may be an option in the northern growing regions where PM pressure is heavier and the pathogen much more destructive.

- Tebuconazole in spilt applications may be more efficacious and cost effective so further testing is planned.

Soybean yield in the southern growing area of NSW was not heavily penalised by PM infections. There was also no significant impact on protein levels or seed size caused by the PM infection that occurred during the 2013–14 season. However, the severity of the infections in this area is considered mild compared with the northern growing regions where PM can cause total leaf desiccation and loss.

The results show that for growers growing only for the stock-feed market, Djakal is a robust choice given its steady yield potential and known resistance to PM. However, growers interested in growing the white hilum varieties (Snowy, Bidgee and the new line N005A-80), which are preferred by the human consumption market for the production of high quality soy milk and tofu products, may need to consider the use of protectant fungicides to reduce their risk to losses caused by PM if high pressure seasons occur.

One outcome of this research was to raise the question of how the PM infection level observed in the southern regions compares with those observed in the north, so that an understanding of the comparative risk to PM can be assessed.

Summary

Powdery mildew is a major disease of soybeans in tropical and semi-tropical regions that has appeared in the Riverina in the last three seasons. This experiment to evaluate variety susceptibility and fungicide efficacy found:

- Djakal has PM resistance
- other varieties show susceptibility to PM
- new chemistries are effective in PM control
- split application of fungicide can have excellent results
- a need to investigate how the severity of PM infection in the southern growing regions compares with those observed in the more northern regions
- NSW DPI will continue to research new breeding lines with PM resistance.

Acknowledgements

The experiment is part of the *Southern NSW soybean agronomy* project (DAN00192, 2014–2018) jointly funded by GRDC and NSW DPI.

Technical assistance was provided by John Dando and Paul Morris.

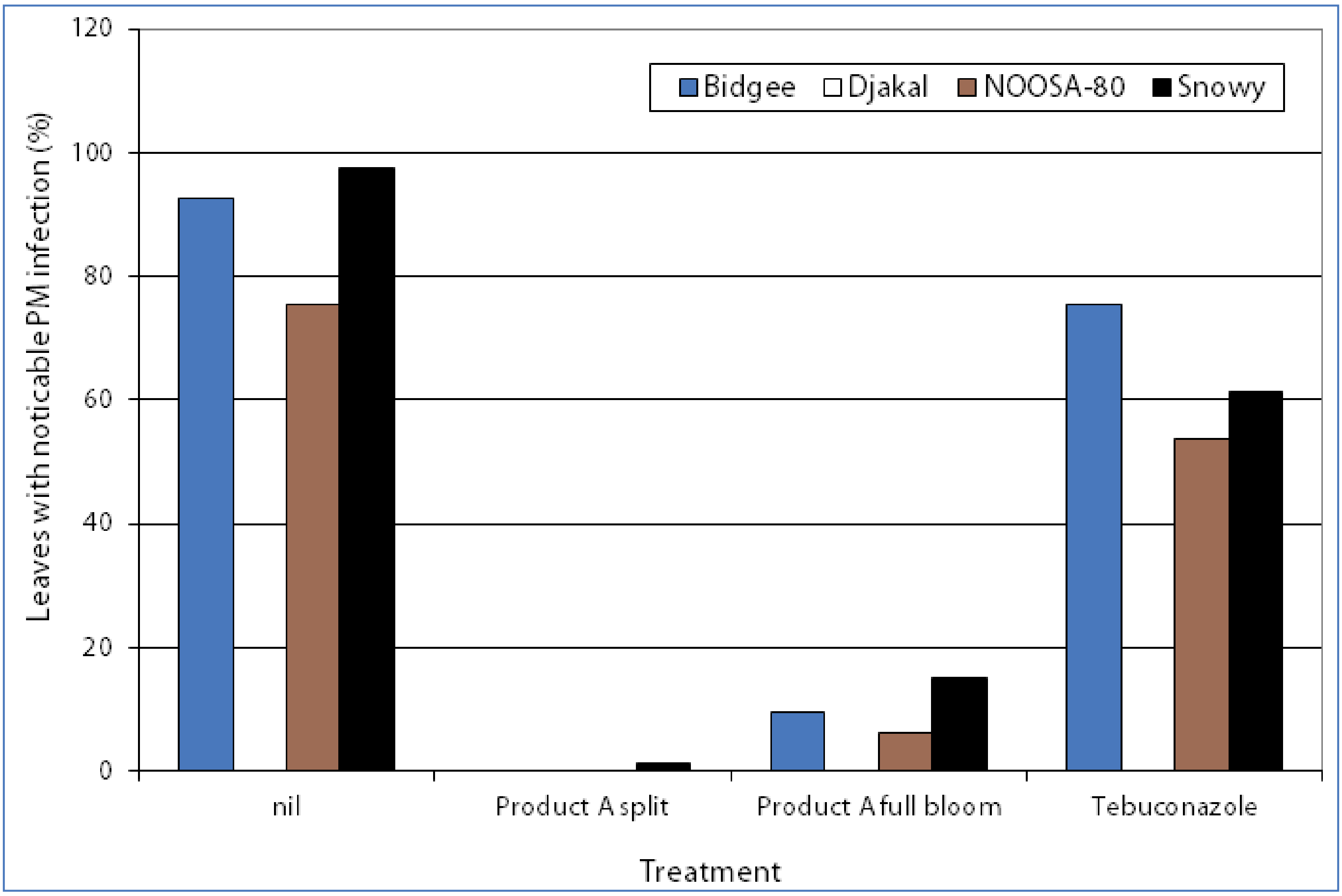

Figure 1: Fungicide efficacy on powdery mildew.

Simulating early season thrips damage in cotton in southern NSW

Dr Jianhua Mo, Dr Sandra McDougall and Scott Munro NSW DPI, Yanco

Introduction

The cotton industry in southern NSW has expanded from a negligible area less than a decade ago, to 53,400 ha harvested in 2012, and 41,000 ha in 2013.

Southern cotton growers reported having to control thrips during establishment. Early sprays against thrips can disrupt the natural enemy complex very early in the season, potentially leading to outbreaks of secondary pests such as spider mites, aphids and whiteflies.

Previous research has shown that cotton has the potential to recover from thrips damage. However, this is influenced by thrips population density and duration of infestation, with recovery poorer from high populations that persist longer. Sufficient crop compensation is also less likely in shorter-season regions such as southern NSW.

This experiment was a preliminary investigation of simulated thrips damage in establishing cotton, similar in design to previous trials conducted in the north of the state. The aim was to compare cotton plant compensation after complete defoliation at the 2, 4 and 6 leaf stage, 75% defoliation at the 2, 4 and 6 leaf stage and no defoliation.

Key findings

- Complete defoliation of 75% and 100% of all plants in early season cotton reduced plant size, abundance of flowers and bolls.
- Defoliation delayed boll maturity by over 10 days and lint yield by over 20%.
- Compensation by un-defoliated plants adjacent to defoliated plants in the 75% defoliation treatment were insufficient to offset the loss sustained by neighbouring defoliated plants.
- The reason was likely because many bolls in the un-defoliated plants failed to mature at the time of harvest.
- This result was different to findings of a similar study in the north; however, more trials are needed to confirm the differences.

Site details

Location	Huddersfield, Darlington Point, NSW
Variety	Cotton 74BRF
Seed treatment	Dynasty D2
Previous crop	cotton
Block	H21, watered up 15 October 2013
Row length	800 m (each plot 20 m)
Beds	1.8 m
Rows	850 cm apart
Plot	20 m x 3 rows (monitor central row)

Treatments

Control	No damage
100% damage	Removal of all leaves from all plants in the plot at the 2, 4 and 6 leaf stage
75% damage	Removal of all leaves from 75% of the plants in the plot at the 2, 4 and 6 leaf stage

Plant measurements

Plant measurements were taken weekly on 5 plants per treatment per plot (i.e. in the 75% of plants defoliated plots, 5 undamaged and 5 damaged plants were sampled) approximately 10 days after last treatments applied.

Plant measurements included height, numbers of nodes, flowers and bolls.

Harvest

Just prior to the neighbouring crop being commercially harvested, 2 m row of each plot was hand harvested, removing cotton from open bolls.

A second harvest of late-opening bolls took place a week later when the commercial harvest was also delayed due to the number of unopened bolls. Opened bolls were hand ginned at Narrabri.

Results

Plant height

Defoliated plants were consistently shorter than un-defoliated plants throughout the monitoring period, with the largest height reduction observed in defoliated plants in the 75% defoliation treatment (*Figure 1*). Intact plants in the 75% defoliation treatment were slightly shorter than those in the control but much taller than those in the 100% defoliation treatment.

Number of flowers and bolls

Defoliated plants consistently had fewer flowers and bolls than un-defoliated plants (*Figure 2*). In the early stage, abundance of flowers and bolls was almost identical within the two groups of intact plants (75%C and control) and within the two groups of defoliated plants (75%D and 100%). However, noticeable within-group differences emerged after late January. In the intact group, more flowers and bolls emerged in plants in the 75% defoliation treatment than in the control. In

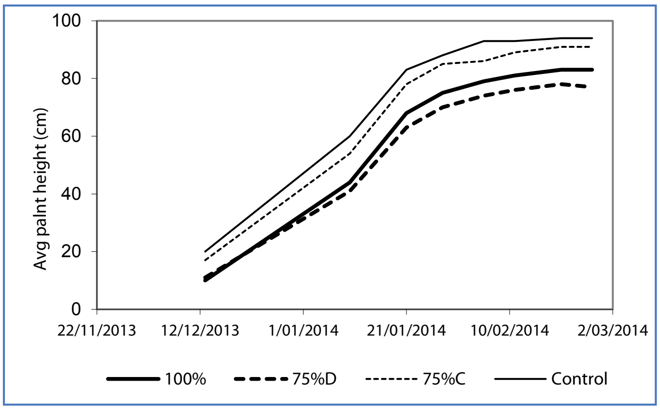

Figure 1: Effect of defoliation on plant height (cm). 75% D: defoliated plants in the 75% defoliation treatment, 75% C: intact plants in the 75% defoliation treatment, 100%: plants in the 100% defoliation treatment, Control: plants in the no-defoliation treatment.

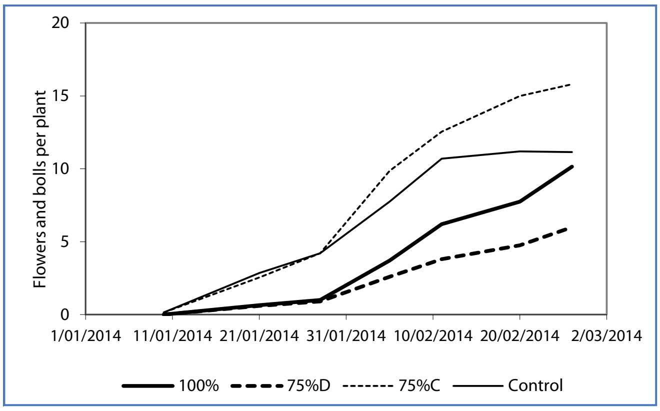

Figure 2: Effect of defoliation on the abundance of flowers and bolls. 75%D: defoliated plants in the 75% defoliation treatment, 75%C: intact plants in the 75% defoliation treatment, 100%: plants in the 100% defoliation treatment, Control: plants in the no-defoliation treatment.

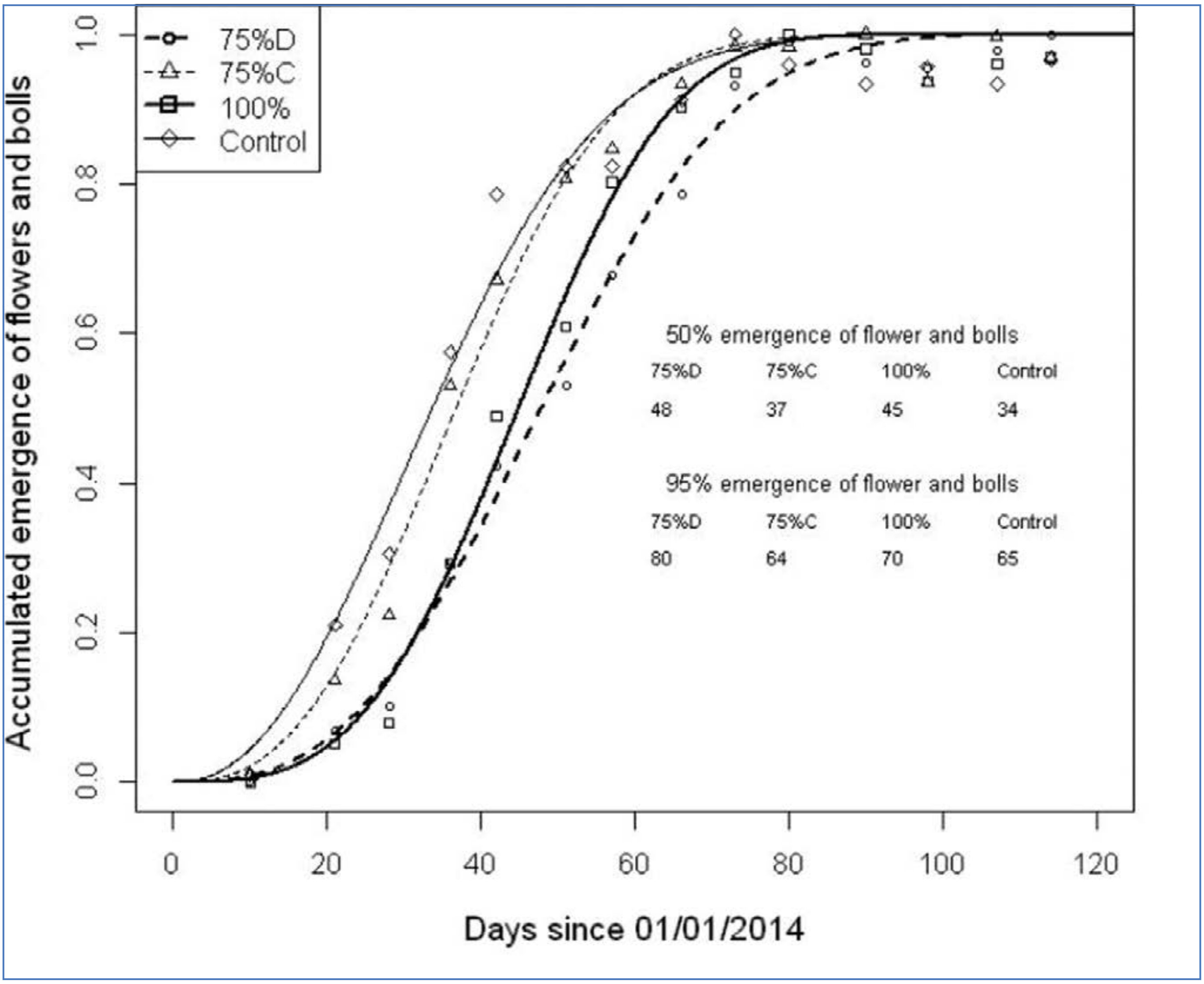

Figure 3: Effect of defoliation on timing of flower and boll emergence. 75% D: defoliated plants in the 75% defoliation treatment, 75% C: intact plants in the 75% defoliation treatment, 100%: plants in the 100% defoliation treatment, Control: plants in the no-defoliation treatment. Lines are fitted Weibull distributions.

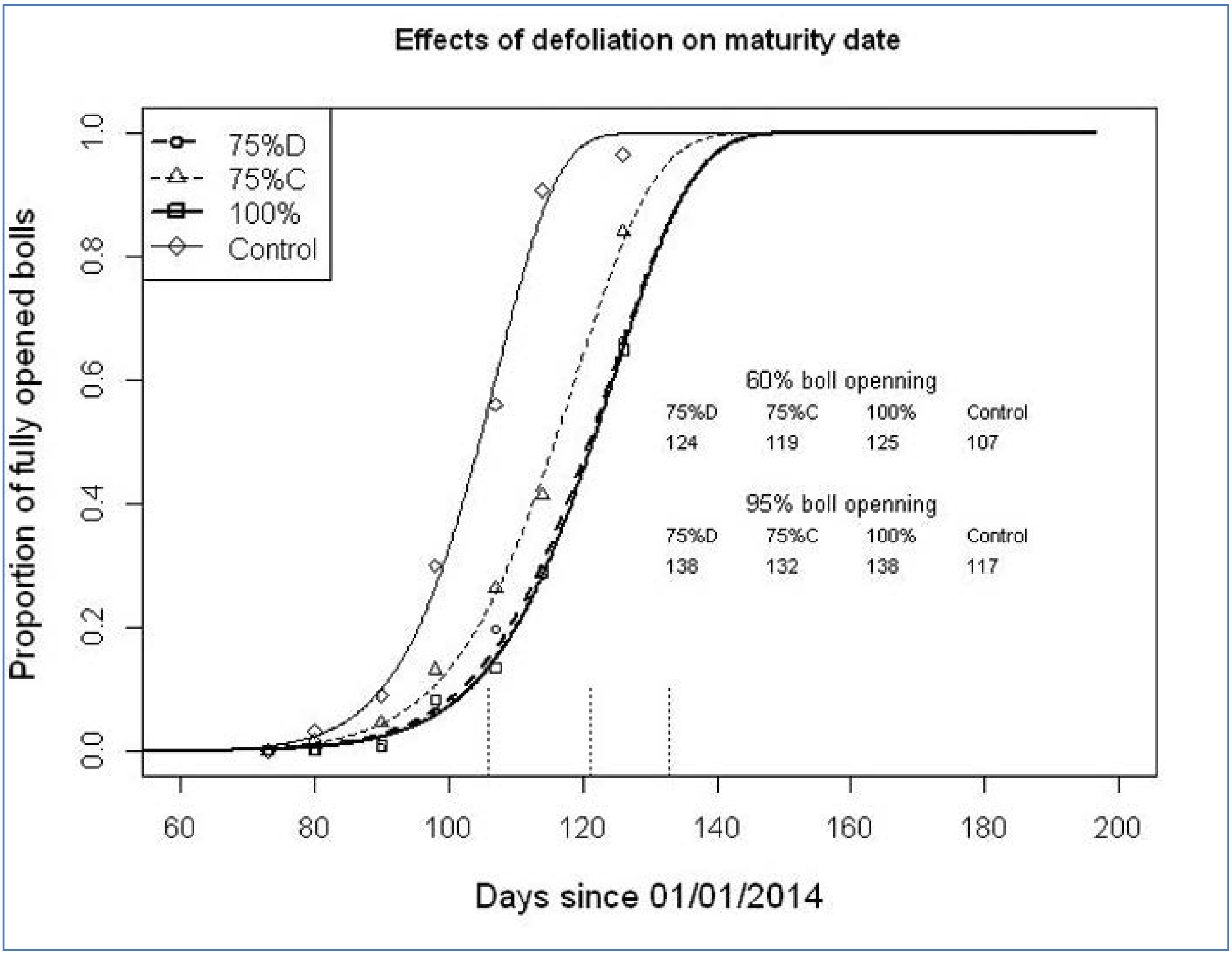

Figure 4. Effect of defoliation on maturity dates in a defoliation experiment in Huddersfield, Coleambally, during December 2013 and May 2014. 75%D: defoliated plants in plots receiving the 75% defoliation treatment, 75%C: un-defoliated plants in plots receiving the 75% defoliation treatment, 100%: plants in plots receiving the100% defoliation treatment, Control: plants in un-defoliated plots. Solid lines are fitted Weibull distributions. Dotted lines show the dates when defoliants were applied.

the defoliated group, more flowers and bolls emerged in the 100% defoliation treatment than in the 75% defoliation treatment.

Boll maturity

Median emergence date of flowers and bolls in defoliated plants was delayed by over 10 days (*Figure 3*) as compared to intact plants. Boll maturity (60% boll opening) was delayed by over 16 days (*Figure 4*). Interestingly, boll maturity of intact plants (75%C) adjacent to defoliated plants (75%D) was also delayed by 12 days.

Lint weight

Defoliation significantly affected lint weight (f=8.39, df=2, 6, $P<0.05$), with significantly lower lint weight in both the 75% and 100% defoliation treatments in comparison to the control (24%–31% reduction) (*Figure 5*). However, defoliation did not affect percentage of gin-out (40%–41%) (f=0.48, df=2, 6, $P>0.1$).

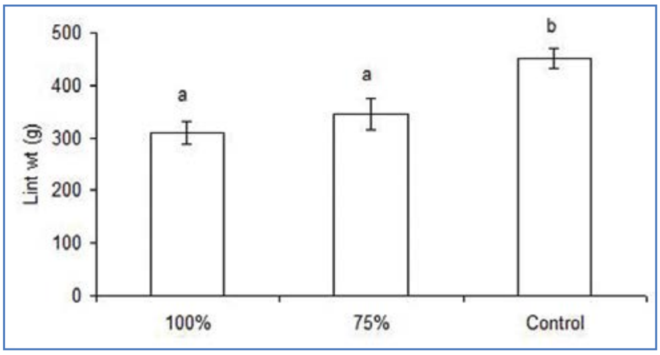

Figure 5: Effect of defoliation on lint weight. Columns labelled with different letters are significantly different at P<0.05 by Fisher's LSD test following detection of significant treatment effects by ANOVA.

Summary

Complete defoliation of 75% and 100% of plants in early season cotton reduced plant size, and abundance of flowers and bolls. Boll maturity was delayed by more than 10 days and lint yield decreased by more than 20%. Some compensation in plant height and abundance of flowers and bolls was observed in intact plants adjacent to defoliated plants during later crop stages, however, the amount of compensation was insufficient to offset the loss sustained by neighbouring defoliated plants. The reason was likely because many bolls in the intact plants failed to mature at the time of harvest. This result did not agree with the findings of a similar study in the north, however, more trials are needed to confirm the differences.

Acknowledgements

This experiment (DAN1501, 2014–2017) jointly funded by Cotton Research and Development Corporation and NSW DPI.

Thanks to Ross Askins at Huddersfield for allowing us to defoliate his cotton seedlings. Also to Lewis Wilson, CSIRO ACRI for advice and Simone Heimenoa for hand-ginning the cotton samples at Narrabri.

New insecticides for thrips control in cotton

Dr Jianhua Mo, Dr Sandra McDougall, Scott Munro and Dr Mark Stevens NSW DPI, Yanco

Introduction

Thrips are common seedling pests of cotton in most growing districts. They feed on growing terminals causing leaf distortion and sometimes death of the terminals. Heavy infestation may result in yield loss and delaying of maturity. Currently registered insecticides for thrips control in cotton are mostly Organo-Phosphates, which are highly toxic and disruptive to beneficial insects. To find options more compatible with IPM, we evaluated four new-generations insecticides that are either specialist against sap-sucking insects or known to have thrips control potential.

Key findings

- Transform®, Exirel®, Mainman®, and Success® Neo all showed potential for thrips control in cotton.
- Success® Neo and Exirel® demonstrated higher efficacy than the other two insecticides.
- Main thrips species in this experiment was tobacco or onion thrips (*Thrips tabaci*).
- Western flower thrips (*Franklinella occidentalis*) was present at very low levels (<5%).

Site details

Location	Coleambally Demonstration Farm
Trial period	19 November - 11 December 2014
Co-operators	Matt Toscan and Ben Witham
Sowing date	8 October 2014
First water	8 October 2014
Variety	74BRFD
Irrigation	Furrow
Plot size	90 cm single rows x 3 rows x 15 m = 0.00405 ha
Establishment	10 plants/m^2

Treatments

Table 1. Insecticides and rates tested in the experiment.

Name	Active	Rate	Adjuvant
Transform®	240 g/L sulfoxaflor	300 mL/ha	Agal®, 10 mL/100 L
Exirel®	100 g/L cyantraniliprole	600 mL/ha	Hasten®, 500 mL/ 100 L
Mainman®	500 g/kg flonicamid	400 g/ha	Nil
Success® Neo	120 g/L spinetoram	400 mL/ha	Agal®, 10 mL/100 L
Water Control			

Experiment details

Trial design	Complete randomized plots
Replicates	4
Buffer	1 row either side, 2 m along rows
Spray applicator	Battery powered 15L backpack sprayer (Rapid Spray®)
Water rate	200 L/ha
Spray dates	20 and 27 November 2014
Monitoring dates	19, 27 November, 4 and 11 December 2014
Sample unit	10 plants (aerial parts only) from centre row
Monitored	Thrips adults, nymphs and species composition
Analysis	ANOVA, significant treatment effects were detected ($P < 0.05$), treatment means were separated by Fisher's LSD.

Results

The crop was at 4–6 leaf stage at the start and 18–20 leaf stage at the end of the experiment. Prior to the first spray, adult thrips density averaged 8–10/plant and larval thrips density 40–60/plant, and there were no significant differences between the treatments in either the adult or larval thrips density (*Figure 1*). Significant treatment effects were detected at 14 and 21-d after the first spray for adult thrips and 7, 14, and 21-d after the first spray for larval thrips (*Table 2*).

For adult thrips, Transform®, Mainman®, and Exirel® significantly reduced thrips numbers at 14-d after the first spray or 7-d after the second spray, with Exirel®

Table 2. Overall differences in adult and larval thrips densities between the treatments before and after sprays as revealed by ANOVA.

	Adult thrips			Larval thrips		
Date*	F	DF1,2	P	F	DF1,2	P
1 DBS1	0.33	4, 15	0.8544	2.58	4, 15	0.0796
7 DAS1	1.27	4, 15	0.3243	6.61	4, 15	0.0028
14 DAS1 and 7 DAS2	7.27	4, 15	0.0018	8.42	4, 15	0.0009
21 DAS1 and 14 DAS2	5.82	4, 15	0.0049	7.05	4, 15	0.0021

*DBS1, DAS1, and DAS2: days before the first spray, and day after the first and second sprays.

significantly outperforming the other two insecticides, reducing thrips density by about 32% as compared with the control ($P < 0.05$) (*Figure 1*). No significant effect was detected for Success® Neo on this date. One week later, adult thrips density in all plots bounced back, with none of the four insecticides performing better than the control. In fact, Transform® and Success® Neo treated plots had significantly more adult thrips than control plots. This surprising result may have been due to new influx of adult thrips from outside and/or inter-plot movements of the adults thrips at the site.

Treatment effects were more clearly seen in larval thrips (*Figure 2*). All four insecticides showed significant efficacy against larval thrips density on all three post-treatment occasions. Success® Neo outperformed

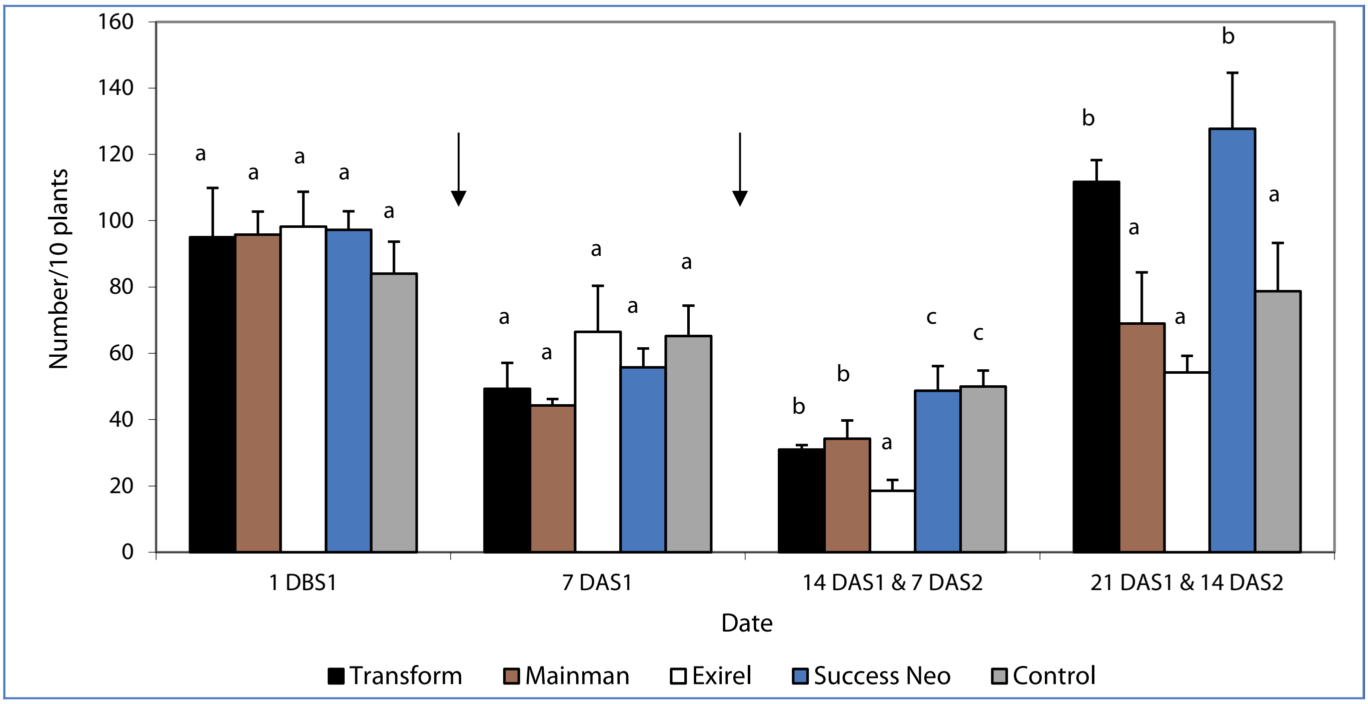

Figure 1: Mean adult thrips densities before and after sprays. Bars in the same group labelled with different letters are significantly different at P = 0.05 by Fisher's LSD following the detection of significant overall treatment effects by ANOVA. Error bars show the standard errors. Arrows show timing of sprays. DBS1, DAS1, and DAS2: days before the first spray, and day after the first and second sprays.

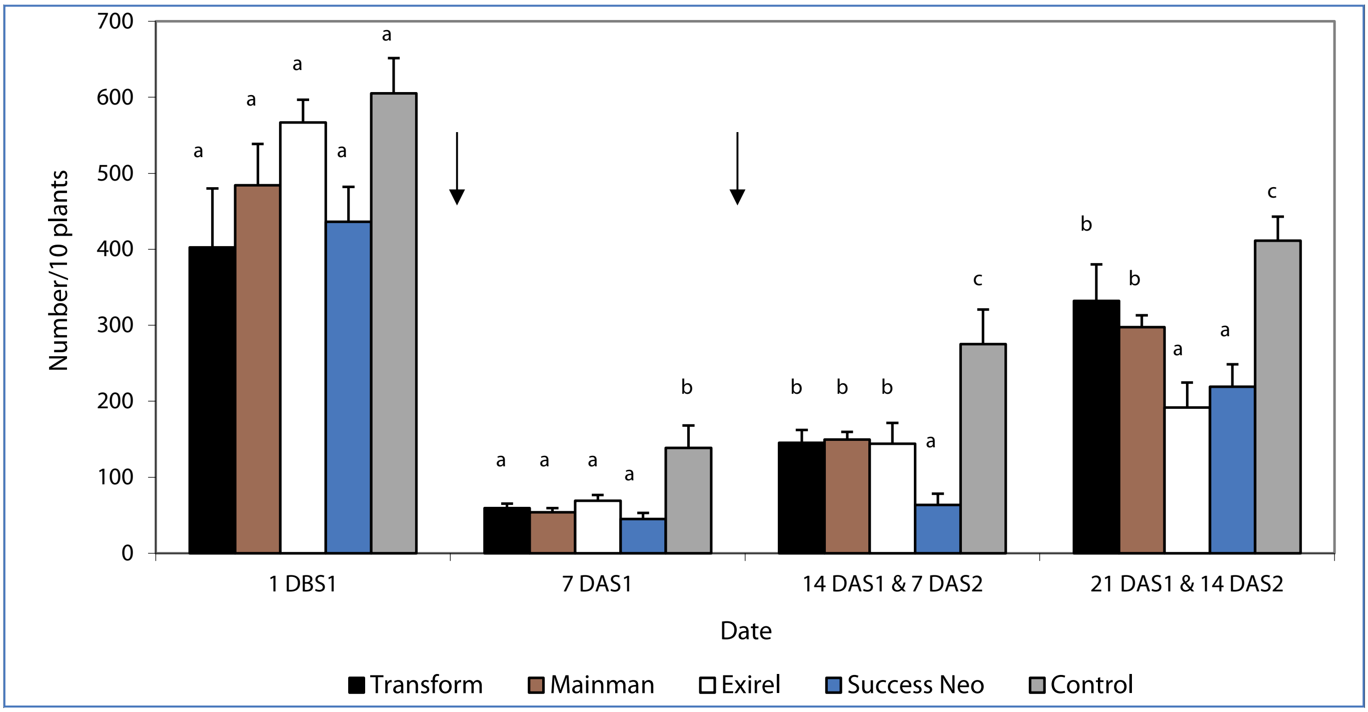

Figure 2: Mean larval thrips densities before and after sprays. Bars in the same group labelled with different letters are significantly different at P = 0.05 by Fisher's LSD following the detection of significant overall treatment effects by ANOVA. Error bars show the standard errors. Arrows show timing of sprays. DBS1, DAS1, and DAS2: days before the first spray, and day after the first and second sprays.

Transform® and Mainman® on two occasions and Exirel® outperformed the same two insecticides on one occasion. In comparison to the control, all four insecticides reduced larval thrips by at least 50% 7-d after the first spray, with reduction rate as high as 77% for Success® Neo 7-d after the second spray.

As part of a separate investigation, three plant samples were collected at the site during the experimental period. Of all thrips adults extracted from the plant samples, 67-85% were tobacco or onion thrips (*Thrips tabaci*). The next most common thrips species was tomato thrips (*Frankliniella schultzi*) (15-24%). Western flower thrips (*F. occidentalis*) was present at a very low level (< 5%).

Summary

A small-plot experiment was conducted in a commercial cotton crop (74BRFD) in Coleambally, NSW, during 19 November – 11 December 2014, to evaluate the efficacy of four new insecticides, Transform®, Exirelv, Mainman®, and Success® Neo in controlling thrips in cotton seedlings. The results showed all four insecticides were effective against thrips, reducing larval thrips by at least 50% within a week of a single spray. More trials are needed to determine the general thrips-control efficacy of these insecticides and their activities against different thrips species, in particular western flower thrips.

Acknowledgements

This experiment (DAN1501, 2014–2017) jointly funded by Cotton Research and Development Corporation and NSW DPI.

We greatly appreciate the co-operation of the Coleambally demonstration farm committee and the grower co-operators: Matt Toscan and Ben Witham. Thanks to Dupont, Dow and UPL for supplying insecticides for the experiment and CSD for supplying seed. Thanks to Glenn Morris for assisting with spraying.

Rice Partnership – rice breeding and quality

Dr Peter Snell, Ben Ovenden and Laura Pallas NSW DPI, Yanco

Key findings

- Topaz – new jasmine-style fragrant variety released in August 2014
- Two advanced cold tolerant breeding lines to replace Reiziq are in the pure seed scheme and commercial release contingent on market feedback.
- Two short growth advanced breeding lines for the sushi market are at Breeders seed stage.
- Super-soft cooking long grain – is doing well with eating quality but tends to lodge.
- Firm-cooking long grain cold tolerant replacement for Doongara progressing.

Introduction

The NSW DPI rice breeding program has been closely associated with the rice industry since the beginning of commercial production in the 1920's. A collaborative agreement between NSW DPI, RIRDC and SunRice formed the *Australian rice partnership* project which has operated from 2011.

The *Australian rice partnership* encompasses a rice breeding and grain quality program to provide new varieties to NSW rice growers. All facets of rice variety development, from the initial cross through to commercial release are covered, including the generation of broad genetic variability and subsequent phases of selection and purification.

Site details

F1 generations	glasshouse (YAI)
F2 and F3 generations	field – Leeton Field Station (LFS)and/ or RRAPL)
F4 generations	field short row trials –LFS
F5 generations	field replicated long row trials – LFS and RRAPL
Advanced lines	field replicated trials – LFS, RRAPL and district trials
Advanced lines	breeders seed
Advanced lines	pure seed scheme
Commercial lines	pure seed scheme - 30 ha seed increase blocks

Method

The Rice Breeding program follows a modified pedigree breeding program with approximately 500-700 crosses to be carried out each year, including complex crosses and when appropriate augment with single seed descent methodology.

F2 seed is produced in a glasshouse. For complex F1 crosses and some selected F2 material, individual plants are grown and leaf tissue used for genotyping for marker assisted backcrossing.

F2 seed is sown in bulk populations in the field and selection carried out for the simple, highly heritable traits such as plant stature and maturity. Selected panicles are progressed over 2 seasons to F4 shortrows. Selected F4 rows are harvested in bulk and allocated to grain quality categories for subsequent plot testing for yield. In total approximately 28,000 individual shortrows are grown at Leeton Field Station (LFS) each season.

Single randomised complete block design field trials (drill-sown only) are used for plot testing broad maturity and quality class, enabling the measurement and selection of lines for phenotypes including maturity, uniformity, yield and grain quality. Approximately 5,200 plots in replicated trials are grown at LFS each season.

Selections of F2 and F3 seed are tested in specific nursery field trials to test for tolerance, straight-head and blast tolerance, and selections are re-incorporated into Breeding trials in the F5 generation. Selected lines then enter replicated testing at a single location (LFS) and the best lines from within each replicated experiment will be tested in two locations (LFS and Rice Research Australia Pty Ltd [RRAPL]- Jerilderie). Field phenotypic measurements are taken from these lines as well as textural attributes and for amylose content. Approximately 2,500 plots are grown in replicated trials each season. Advanced lines are evaluated in trials in each of the production areas on commercial rice farms prior to release as a viable commercial variety. Once a variety is formally released as a new variety it enters the pure seed component that is managed by RRAPL and Sunrice.

Measuring rice quality is integral for selection of varieties to meet the grain qualities for the targeted rice grain market categories. The Quality Evaluation Program (QEP) covers routine measurements such as percentage whole grain, grain dimensions, milled rice colour and chalk within the grain and gelatinisation temperature (GT). On average QEP will assess milling quality of 5000 breeding lines followed by a subset of 2000 breeding lines assessed for wet chemistry/cooking. Up to 1000 early generation lines per year will be also assessed for GT.

Results

Over the past three decades, improvement in genetics through enhanced cold tolerance and shorter growth duration has been responsible for about half of the industry wide increase in productivity per hectare (from an average of 5 to an average of 10 t rice per hectare, and associated increase in the water use efficiency from 0.3 to 0.9 t/ML of irrigation water). Over the same period, the number of rice quality classes available for growers has increased from two (medium and long grain) to seven (medium grain, bold medium grain, Sushi style short grain, Arborio, soft cooking long grain, low-GI long grain, fragrant Jasmine style long grain). This increases the range and value of the markets available for NSW grown rice. Breeding and chemistry research have also played an important role in ensuring rice varieties have the quality properties required for processing rice into cooked products and food ingredients, which has been a key prerequisite in the development of new manufacturing operations for value-adding to NSW grown rice.

In 2014, a new fragrant Jasmine style long grain rice was released as "Topaz". Improved lines for the other six rice quality classes continue to be selected within the breeding program.

Summary

Australian rice varieties have all been a result of the rice breeding program based at NSW DPI's Yanco Agricultural Institute. The success of the program is largely due to the close collaboration between NSW DPI, SunRice and RIRDC which in 2011 was formalized as a partnership. Varieties released from this program meet the goals of improvements in yield and agronomic traits as well as meeting the consumer quality requirements for each of the rice quality classes. This success is due to the close integration with the rice quality research team, combined with close links with the SunRice marketing group.

Acknowledgements

This work is undertaken as part of the *Australian Rice Partnership* (PRJ007256, 2010–2015) jointly funded by Rural Industries Research and Development Corporation, SunRice and NSW DPI.

Managed Environment Facility—Yanco

Kathryn Bechaz, Dionne Wornes and Peter Davidson NSW DPI, Yanco

Introduction

The NSW DPI Yanco Agricultural Institute hosts one of the Managed Environment Facilities that is part of a $1.6 million Grains Research and Development Corporation (GRDC) investment. The project was established in January 2011 and is funded until June 2015. As a national research facility (other sites include Merredin, WA and Narrabri, NSW), the Yanco Managed Environment Facility site is supporting evaluation of germplasm from research institutions across Australia.

Research projects

Research projects that operate on the site are from CSIRO, Western Australia Department of Agriculture and Food (DAFWA), NSW Department of Primary Industries, University of Adelaide, University of Sydney and Australian Grains Technology (AGT) Wheat Breeding.

These projects include a series of bread wheat benchmarking trials, heat shock experiments, Durum wheat trials, a range of experiments involving the evaluation of plant modelling and diverse breeding traits (CSIRO trials), and a rainout shelter experiment to further limit the amount of water available to wheat varieties.

Research projects aims

- To assess drought tolerant traits (such as early vigour, reduced tillering and stem carbohydrates) in various germplasm.
- It is hoped that assessment of these traits will enable researchers to target the better traits for breeding purposes.
- To improve the understanding of the genetics involved with heat-stress tolerance.

Site details

Location	Yanco Agricultural Institute
Soil type	red-brown sand to a red-brown clay loam
2013 Crop	wheat
2012 Crop	field peas as a brown manure crop
Planting date	from late May to late June
Sowing rate	80 kg/ha
Fertiliser applied	100 kg/ha of granulated MAP treated with Intake fungicide at 200 mL/100 kg
Trials	Wide range of trials including irrigated, dryland (rainfed) and heat shock trials

Key points

- The facility provides essential infrastructure and support for field research projects directed towards identifying adaptive traits and management strategies for improved productivity of field crops growing in water limited or drought-prone environments.
- The site is a world-class field research facility for improving the accuracy and reliability of germplasm characterisation (phenotyping) to quantify the contribution of individual traits to water use efficiency.

Treatments

Core measurements:

- plant measurements—plant establishment counts, ground cover assessments (greenseeker and photos), maturity of plants using Zadoks growth stages, anthesis (flowering) cuts, crop canopy temperature, lodging scores, plant heights, plot lengths, harvest index cuts and harvest plot weights
- grain quality measurements—100 grain weight, hectolitre weight, <2 mm sieve weight and screenings
- soil water measurements—knowledge of soil water content using a neutron probe.

Figure 1: Travelling irrigator watering a crop at the Managed Environment Facility.
Photo: K Bechaz

Summary

Yanco is representative of a dryland, water-limited environment and research conducted at the Yanco facility will identify traits that form the basis for increased yield and quality of broadacre crops (with emphasis on cereals) in the low and variable rainfall zones of Australia. Such yield and quality improvements are needed to sustain the grains industry under the current conditions of low rainfall and seasonal variability and the predicted impacts of climate change.

Acknowledgements

This project (DAN00137, 2010–2015) is jointly funded by GRDC, CSIRO, Western Australia Department of Agriculture and Food, NSW DPI, University of Adelaide, University of Sydney and Australian Grains Technology (AGT) Wheat Breeding.

Figure 2: Irrigated trials with rainout shelter in background at the Managed Environment Facility.
Photo: K Bechaz.