RiverinePlains

Research for the Riverine Plains 2013

A selection of research relevant to agriculture in the Riverine Plains

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Research for the Riverine Plains 2013

Farmers promoting excellence in farming systems by providing quality information, leading research and sharing ideas for the economic, environmental and social benefit of the Riverine Plains.

Compiled by Fiona Hart
Technical editing by Michelle Pardy and Allison Glover
Sub-editing by Hot Tin Roof Communications
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NSW GOVERNMENT Primary Industries

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Acknowledgements

Welcome to the 2013 edition of the Riverine Plains trial book. This year we have our usual array of articles, from reports on variety trials and stubble retention to break crops and the never-ending challenge of annual ryegrass control. We trust you find the local perspectives valuable.

On behalf of Riverine Plains Inc, I'd like to formally thank all the authors for their submissions. We sincerely appreciate the efforts of our contributing research organisations and industry bodies in sharing their results with the Riverine Plains' membership.

We particularly recognise the ongoing support provided by the Grains Research and Development Corporation (GRDC), which enables our locally-based research work to continue. Special thanks to all the researchers, agronomists, trial contractors, industry representatives and farmer co-operators involved in carrying out the group's diverse research portfolio.

I would personally like to congratulate the Riverine Plains Inc Research Committee for their hard work in planning and carrying out the Riverine Plains research program so thoroughly and professionally. I especially acknowledge the role our Research Co-ordinator, Allison Glover, plays to support the development of this portfolio.

We also thank the Department of Environment and Primary Industries Victoria and NSW Department of Primary Industries for their contributions and continued involvement and support of the group.

A very special thanks to Fiona Hart and Allison Glover for obtaining the articles and working hard to get the book published. Thanks also to sub-editor Catriona Nicholls and graphic designer Josephine Eynaud for producing a readable and visually-appealing final product.

We hope you find this year's range of articles valuable and we wish you all the best for the 2013 cropping season.

Michelle Pardy
Technical Content Editor



Contents

Area covered by Riverine Plains Inc

Membership area



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more give, less take

Source: RBA Banking System/NAB APRA submissions December 2012.

Units of measurement

Row spacings

Some trials carried out during 2012 have investigated the effect row spacings play in crop production.

Riverine Plains Inc recognises that while the research sector has moved toward metric representation of row spacings, most growers remain comfortable with imperial measurements.

Following is a quick conversion table for handy reference when reading the following trial result articles.

TABLE 1 Row spacing conversions

Inches	Centimetres
7.2	18.0
9.0	22.5
9.5	24.0
12.0	30.0
14.4	36.0
15.0	37.5

Standard units of measurement

Through this publication, commonly-used units of measurement have been abbreviated for ease of reading they include:

centimetres — cm

gigahertz — GHz

hectares — ha

kilograms — kg

kilojoules — kJ

litres — L

metres — m

millimetres — mm

tonnes — t



Cereal growth stages

Why are they important to cereal growers?

A growth stage key provides a common reference for describing crop development, so we can implement agronomic decisions based on a common understanding of which stage the crop has reached.

Zadoks cereal growth stage

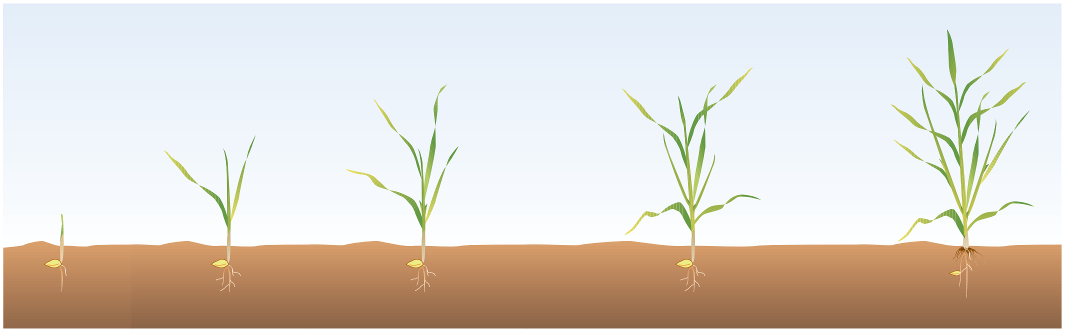
The most commonly used growth stage key for cereals is the:

- Zadoks decimal code, which splits the development of a cereal plant into 10 distinct phases of development and 100 individual growth stages.
- It allows the plant to be accurately described at every stage in its life cycle by a precise numbered growth stage (denoted with the prefix GS or Z e.g. GS39 or Z39)

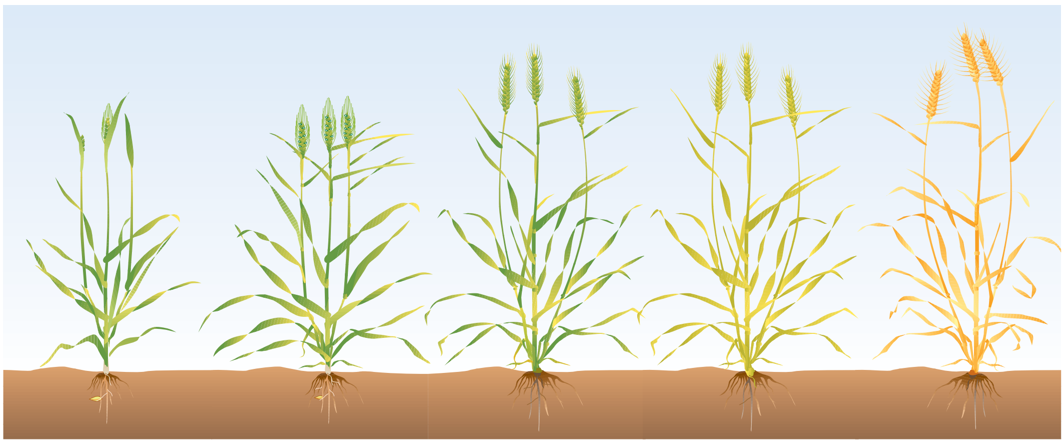
Within each of the 10 development phases there are 10 individual growth stages, for example, in the seedling stage:

- GS11 describes the first fully unfolded leaf
- GS12 describes two fully unfolded leaves
- GS13 describes three fully unfolded leaves
- GS19 describes 9 or more fully unfolded leaves on the main stem

This information has been reproduced with the permission of the Grains Research and Development Corporation (GRDC) and is taken from *Cereal Growth Stages: The link to crop management*, by Nick Poole.



Zadoks growth stage	GS00–09	GS10–19	GS20–29	GS30–39	GS40–49
Development phase	Germination	Seedling growth	Tillering	Stem elongation	Booting



Zadoks growth stage	GS 50–59	GS60–69	GS70–79	GS80–89	GS90–99
Development phase	Ear emergence	Flowering	Milk development (grain fill period)	Dough development (grain fill period)	Ripening

Preface

Trials versus demonstrations — what the results mean

Research on the Riverine Plains takes different shapes and forms, each of which has the potential to make an important contribution to increasing the understanding about agricultural systems in the area. However, it is important to keep in mind results from the different forms of research need to be analysed and interpreted in different ways.

It is important to understand the difference between trials and demonstrations in the use of results for benefit on farms. A replicated trial means that each treatment is repeated a number of times and an averaged result is presented. The replication reduces outside influences producing a more accurate result. For example, trying two new wheat varieties in a paddock with varying soil types and getting an accurate comparison can be obtained by trying a plot of each variety, say four times. Calculation of the average yield (sum of 4 plots then divided by 4) of each variety accounts for variations in soil type.

Statistical tests for example, Analysis of Variance — ANOVA, Least Significant Difference — LSD) are used to measure the difference between the averages. If there is no significant difference between treatments the results will be accompanied by the mark NS (meaning not significantly different). A statistically significant difference is one in which we can be confident that the differences observed are real and not a result of chance. The statistical difference is measured at the 5% level of probability, represented as ‘P<0.05’.

Table 1 shows an LSD of 0.5t/ha. Only Variety 3 shows a difference of greater than 0.5t/ha, compared with the other varieties. Therefore Variety 3 is the only treatment that is significantly different.

TABLE 1 Example of a replicated trial with four treatments

	Treatment	Avg yield (t/ha)
1	Variety 1	4.2
2	Variety 2	4.4
3	Variety 3	3.1
4	Control	4.3
	LSD (P<0.05)	0.5

A demonstration is a comparison of a number of treatments, which are not replicated. For example, splitting a paddock in half and trying two new wheat varieties or comparing a number of different fertilisers across a paddock. Because a demonstration is not replicated results cannot then be statistically validated. For example, it may be that one variety was favoured by being sown on the better half of the paddock. We can talk about trends within a demonstration but cannot say that results are significant. Demonstrations play an important role as an extension of a replicated trial that can be tried in a simple format across a large range of areas and climates.

Demonstrations are accurate for the paddock chosen under the seasonal conditions incurred. However, care must be taken before applying the results elsewhere.

Trials and demonstrations play a different role in the application of new technology. Information from replicated trials is not always directly applicable but may lead to further understanding and targeted research. Demonstrations are usually the last step before the application of technology on farm.



A word from the Chairman

Evan Ryan
Chairman 2011–12

Riverine Plains Inc has had another progressive and successful year with our research and extension programs continuing to deliver benefits to our members and the general farming community.

Generally the 2012 farming year was a profitable and productive one for members across the Riverine Plains region, with grain prices trending upward through the season and yields meeting expectations given the seasonal climatic conditions.

The 2012 year was marked by a number of events and achievements for Riverine Plains Inc.

Our group received more than half a million dollars in funding to start work on an exciting new project, which investigates the accelerated conversion of crop residue into valuable soil carbon. The project aims to trial on farm whether or not more carbon can be accumulated in the soil by 'feeding' the soil biota, which break down crop residues. This project is supported by funding from the Australian Government Department of Agriculture, Fisheries and Forestry (DAFF) as part of its *Carbon Farming Futures — Action on the Ground* program. Project partners include Murray Catchment Management Authority (CMA), North East CMA and the Irrigated Cropping Council.

On behalf of Riverine Plains Inc I would like to thank David Wolfenden, Allison Glover, and Juliet Cullen from Murray CMA for driving this project. Bill Slattery has been appointed as the project officer for this project.

During 2012, agribusiness provided fantastic support to Riverine Plains Inc once again through the form of sponsorship. Our group continues to be successful and that is due, in no small part, to our sponsors' valued contribution. We also recognise the input we receive personally from our sponsors in terms of trial contributions, project advice and input at field days, workshops and other presentations, all of which adds to the success of our group in meeting the needs of growers.

Along with a number of other Victorian Grower Group representatives, our Executive Officer and Deputy Chair attended the WA Grower Group Alliance Annual Conference in Perth, Western Australia during August 2012, further developing our interstate networks.

The Victorian Grower Group Alliance was incorporated during 2012. The Alliance has provided great training, staff development and networking opportunities for our Executive Officer, Fiona Hart. I would also like to acknowledge the role David Wolfenden has played in the Alliance as the Chair.

During the past year, several precision agriculture (PA) workshops took place, with two groups; one located at Rand, New South Wales and the other at Dookie, Victoria. Precision Agriculture Australia (SPAA) facilitated the workshops, which were designed to help improve adoption of PA, demonstrate the benefits and show it is not that difficult to adopt and use in our farming systems.

In the order of 150 growers, researchers and agribusiness representatives attended the Grains Research and Development (GRDC) Update hosted by Riverine Plains Inc at Corowa, NSW on 1 March 2012. The audience heard the latest in grain industry research and extension in preparation for the cropping season. The update delivered timely, high-quality information and provided growers with the chance to hear and to question nationally-renowned researchers and consultants.

Riverine Plains Inc, in conjunction with Birchip Cropping Group (BCG), also hosted two canola workshops at Dookie and Corowa to bring growers up to speed on industry developments and help guide their decisions for the season ahead. The GRDC funded the workshops and brought some of Australia's leading experts to the region to discuss canola agronomy and marketing. In the order of 75 growers and agribusiness representatives attended the workshops.

Riverine Plains Inc, NAB Agribusiness and RSM Bird Cameron held a farm business management seminar *How do I really know if my farm is profitable?* at Corowa on 13 June 2012. The seminar was well attended by an audience of 75. Topics covered included building an asset base outside the farming business, the Carbon Farming Initiative (CFI), practical ways of improving farm profitability and a commodity update.

A timely drop of rain and a reputable and invaluable list of speakers led to more than 140 people attending the Riverine Plains In-Season Update at Mulwala, NSW on 9 August, 2012. Topics of interest included a seasonal outlook, integrated weed management (IWM) research, green/brown manuring, grain storage, canola blackleg genetic lines and canola harvesting.

Farmers inspiring farmers

Growers viewed trials and investigated improving water use efficiency (WUE) at the Spring Paddock Walk, held at the Riverine Plains Inc trial site at Coreen, NSW on 4 September 2012. New Zealand researcher Nick Poole provided a summary of the three years of results investigating the impacts of row spacing in no-till systems. The group of 70 attendees discussed issues including yellow leaf spot and late-season nitrogen (N) and fungicide options for the current crop.

From 24–26 September 2012 a group of 12 growers partook in the 2012 Spring Study Tour. The three-day tour focused on no-till farming systems. The tour started locally in north-east Victoria visiting some local growers around Shepparton before visiting some innovative growers in the Wimmera region.

The Spring Field Day was held on 12 October 2012 at the Inchbold family property south of Yarrawonga, which provided attendees with the opportunity to see the latest canola and wheat varieties, view research into more profitable pulse crops, see Riverine Plains Inc own WUE research as well as visit a plant growth regulator demonstration.

Members of the Riverine Plains Inc committee and staff have also completed two workshops with the assistance of Corowa District Landcare, focussing on governance and running more productive meetings, which will be invaluable for the group's functioning in the future.

With regards to this trial book I congratulate and thank Fiona Hart, Allison Glover and Michelle Pardy for their work in collating this year's trial book. Once again it is of a very high standard and a showcase of the year's work. I look forward to steering the group through another year of accomplishments, which is only possible with the expert guidance of our Executive Officer Fiona, a bright and innovative committee and a broad base of passionate members who are striving to improve their farming system.

2012 — the year in review

Lisa Castleman
NSW DPI, Wagga Wagga

The first four days of March, 2012 marked the start of the season with an extreme weather event in New South Wales, where many producers in the Riverina received 200–275mm (8–11 inches) of rainfall in a 48-hour period (see Figure 1).

There were also heavy falls in north-east and north-central Victoria, with many farms receiving about 140mm during the first four days of the month (see Figure 2).

The Shepparton area received falls of about 93mm for the same period (see Figure 3).

In some areas, such as Billabong Creek, and in many of the upper streams and in townships, such as Lockhart and Urana, this caused flash flooding, which significantly affected landholders.

After dealing with the emergency in the short term, farmers then started repairing damaged or destroyed fences, pipelines, culverts, bridges, farm roads, dam banks, stock troughs, etc (which may go on for months or even years). Lost shelterbelts and tree lines also takes many years to replace.

For some landholders, the 2012 flood was on the back of the flash flood and storm event experienced during October, 2010.

Some growers were eligible for Natural Disaster Relief funding during 2012 in the form of grants for repairs to infrastructure. Others missed out and have worn the entire expense themselves. It serves as a reminder as to how much capital growers have tied up in farm infrastructure. Steel fencing supplies are expensive (although iron ore has dropped in value) as is the cost of fencing contractors and extra farm labour.

On a more positive note, rainfall always presents an opportunity and our farming systems are better equipped than ever to harvest such a rainfall event. A healthy soil with good soil structure copes better with a high-rainfall event, as it has more soil pores and cracks and is less likely to crust on the surface.

The amount of run-off captured on individual farms last year depended on the intensity of rainfall and the sheer volume of water that fell, the slope of the paddock and how quickly the rain soaked in. As the soil became more saturated, the infiltration rate slowed, being driven by the force of gravity rather than water tension. More stubble cover would have helped trap the water and slowed run-off.

The growing season

The yields at the end of the 2012 season reflected the significance of the March rainfall and the amount captured and stored in the soil for later use.

The timing of the rain during early March was opportune for the winter crops. Effectively it formed the start of our autumn and the growing season that followed.

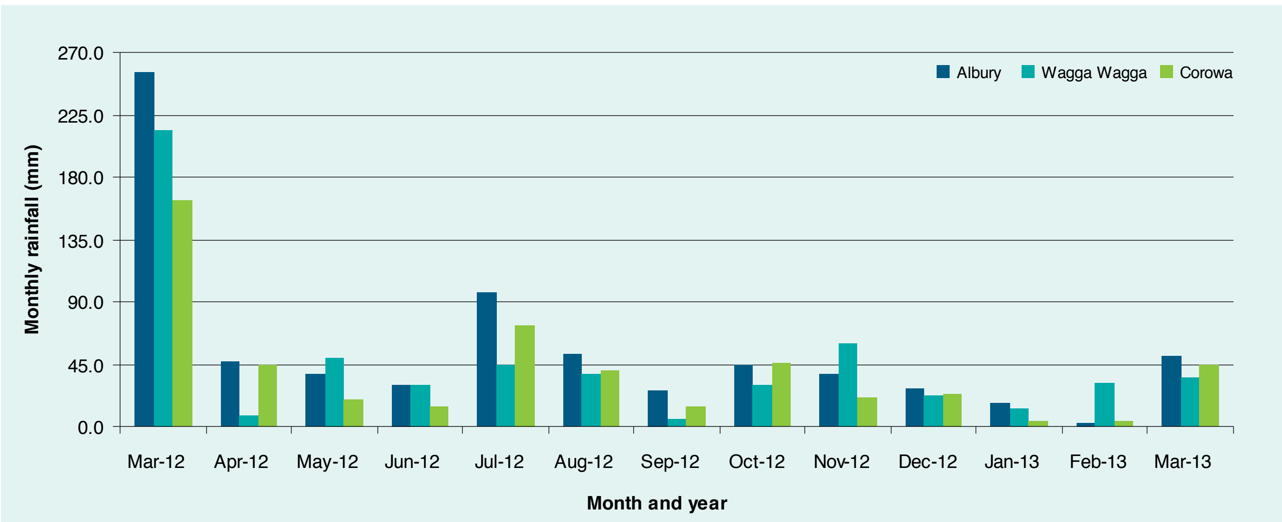


FIGURE 1 Albury, Corowa and Wagga Wagga monthly rainfalls in NSW



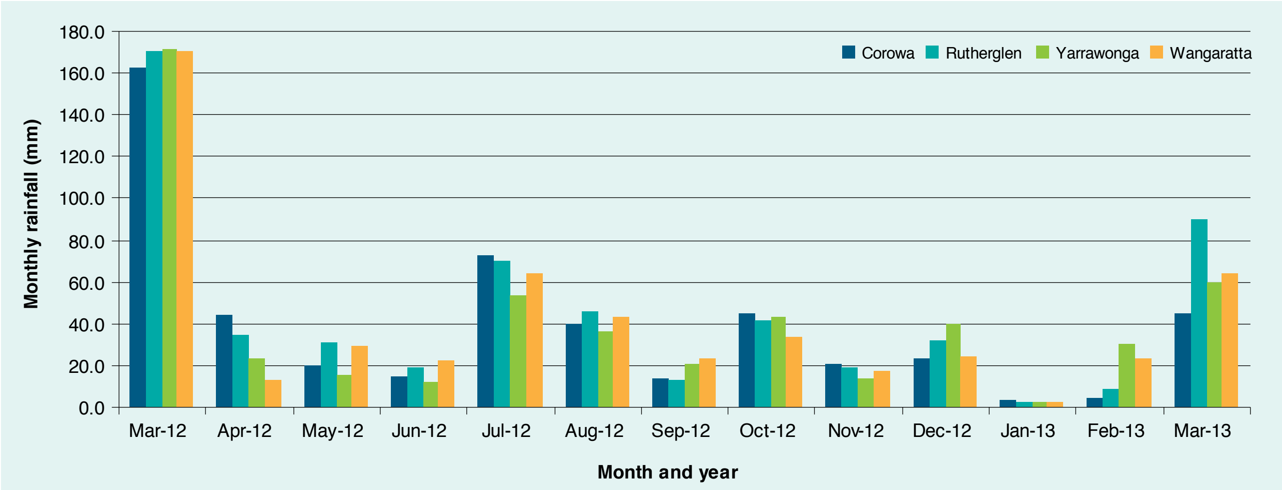


FIGURE 2 Corowa, Rutherglen, Wangaratta and Yarrawonga monthly rainfalls in NSW and VIC

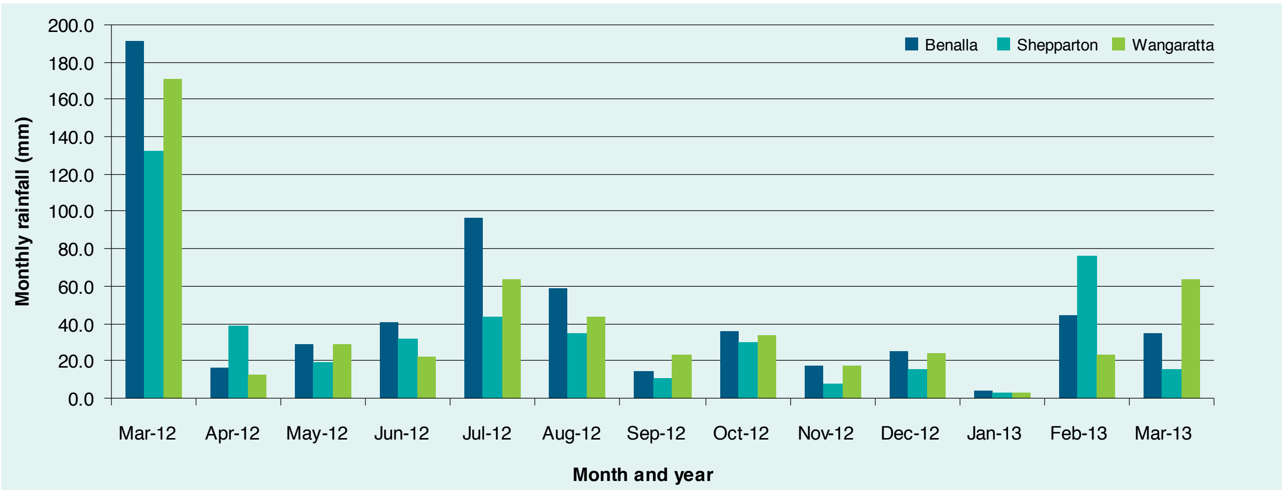


FIGURE 3 Benalla, Shepparton and Wangaratta monthly rainfalls in VIC

The Corowa rainfall data is represented twice, once on Figure 1 and a second time on Figure 2 because of its close proximity to Rutherglen and Yarrawonga. The Wangaratta data is also represented twice, in close proximity and to the north of Benalla and Shepparton and then to the south of Rutherglen and Yarrawonga.

In many cases canola was sown by 15 April. Small areas of lupins also went in around this time and winter wheats went in early, followed by main-season wheats. It was one of our earliest sowings yet, with a consistency across the whole district that is rarely seen.

Back-to-back wheat harvests, with low protein results, saw growers start the season intending to apply more nitrogen to most winter crops, canola and cereals. Unfortunately the March rainfall did not seem to lead to nitrogen gains early during the growing season. Looking back, agronomists now believe nitrogen losses were higher than normal from:

- volatilisation — when ammonium is converted to ammonia gas (favoured by conditions that promote evaporation)
- denitrification — where nitrates in the soil are lost permanently to nitrogen gas and nitrous oxide (supported when soil is saturated and the bacteria use nitrate as a source of oxygen)
- leaching of nitrate down the soil profile.

The short supply of urea in the middle of the growing season was an unexpected issue. And even when urea was on hand it was difficult for growers to time applications from August onwards as fronts blew over and there were few forecasts of rainfall events greater than 5–10mm.

A dry spring meant opportunities for nitrogen mineralisation between September to November were limited (as this biological process requires warm, well-aerated and moist soil). As such, crops did not receive a top-up from available nitrogen in the profile. Due to dry seasonal conditions growers did not apply additional nitrogen

Disease issues

On the crop disease front, many wheat and barley paddocks seemed to be badly affected with rhizoctonia. For 2013, growers who have been seeing rhizoctonia in paddocks year after year have been considering their options: to retire the paddock and put it back to pasture, to cultivate below the seedbed to break up the fungal hyphae (a web of roots of the fungi) or to use a new seed treatment that will reduce the incidence of rhizoctonia. With two new products on the market, new tools are finally available to help better manage rhizoctonia during 2013.

The use of fertiliser-applied fungicides, such as Intake® and Triad®, was also popular during 2012. Growers used these products to control of a number of diseases and they definitely provided prolonged stripe rust control, however, a relatively dry winter coupled with multiple drying frosts meant stripe rust infections were only moderate compared with previous seasons.

Growers seemed more concerned about yellow leaf spot (tan spot) than stripe rust during 2012. Currently, the most effective treatment to reduce YLS is to burn the wheat stubble. However, more growers than ever before are farming on a no-till, full-trash retention, wide-row system and they no longer burn, unless they 'absolutely have to'.

Clearly, there are a number of reasons why growers keep their cereal stubbles or trash. Growers are aiming to improve the infiltration of their soils and their water holding capacity to maintain soil organic carbon instead of watching it decrease during the life of the cropping cycle. They are keen to keep all of the nutrients contained within the stubble itself instead of watching them go up in smoke and to improve air quality (especially if paddocks are located near homesteads or villages). It needs to be quantified whether as a direct consequence of stubble retention (and a decrease in the incidence of burning), the incidence and severity of YLS has changed.

Dr Nick Poole (at the 2012 Riverine Plains Field Day) did not advocate the use of existing foliar fungicides to control YLS. He questioned the economics of using this approach when these fungicides have demonstrated poor control of YLS, require multiple applications and are often applied at less than optimal times when fungicides accompany herbicides.

In summary, the only simple fix for YLS is to burn. As many growers are committed to the system of stubble retention they may need to evaluate whether YLS is causing a significant yield loss and whether there is an economic response from spraying with fungicides.

On a more positive note though, there appears to be some scope for plant breeders to incorporate resistance to YLS in wheat breeding programs. For growers who retain their stubbles, this would be a welcome step instead of 'returning to burn'.

The 2012 season also favoured the development of crown rot and surprisingly the incidence of the pathogen did not seem linked to the cropping rotation (one year's data as discussed by Dr Andrew Milgate at the GRDC Temora Update). As crown rot has long been regarded as a disease of northern NSW, little research funding has been invested in better managing this disease in southern NSW. However, crown rot resistance is a genetic trait that could be selected for in wheat varieties of the future.

All the best for the 2013 season!

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2012 Riverine Plains Inc membership survey — what did it reveal?

During 2012 Riverine Plains Inc carried out an extensive survey of members, the results of which were published in the 2012 edition of *Research for the Riverine Plains*.

This year, further analysis of those 76 responses has been undertaken to determine what the 2012 survey indicated about members' preferences for:

- sowing equipment
- GPS guidance
- changes in stubble management
- yield monitoring
- variable rate technology
- electro-magnetic surveying.

Analysis has been calculated in two ways:

- by hectares cropped, and
- by percentage of farm income derived from cropping.

The results are presented in the following tables.

TABLE 1 Cropping area of survey respondents

Cropping area (ha)	Responses	
	(No.)	(%)
400 or less	19	25
401–800	20	26
801–1590	20	26
1600 or more	17	22
Total	**76**	**99***

* This column does not add to 100% due to rounding of percentages to whole numbers.

TABLE 2 Proportion of farm income derived from cropping

Proportion of farm income derived from cropping (%)	Responses	
	(No.)	(%)
100	28	37
99–75	18	24
74–50	17	22
Less than 50	13	17
Total	**76**	**100**

TABLE 3 Seeder type by cropping area

Seeder type	Cropped area (ha)			
	400 or less	400–800	800–1590	1600 or more
	Responses (%)			
Wide tine (>5cm)	26	20	5	18
Narrow tine (<5cm)	64	55	65	59
Narrow tine and disc	5	15	20	18
Disc	5	10	10	5
Total	**100**	**100**	**100**	**100**

TABLE 4 Seeder type by proportion of farm income derived from cropping

Seeder type	Proportion farm income derived from cropping (%)			
	100	75–99	50–74	<50
	Responses (%)			
Wide tine (>5cm)	28	17	0	15
Narrow tine (<5cm)	54	50	76	69
Narrow tine and disc	18	11	18	8
Disc	0	22	6	8
Total	**100**	**100**	**100**	**100**

TABLE 5 Change in area under retained stubble over past five years by cropped area

Change in area of retained stubble	Cropped area (ha)			
	400 or less	400–800	800–1590	1600 or more
	Responses (%)			
Increased	32	50	85	76
Same	58	40	15	24
Decreased	10	10	0	0
Total	**100**	**100**	**100**	**100**



TABLE 6 Change in area under retained stubble over past five years by proportion of farm income derived from cropping

Change in area of conserved stubble	Proportion of farm income derived from cropping (%)			
	100	75–99	50–74	<50
	Responses (%)			
Increased	79	72	41	31
Same	18	22	59	54
Decreased	3	6	0	15
Total	**100**	**100**	**100**	**100**

TABLE 7 Use of GPS guidance by cropping area

Use of GPS guidance	Cropped area (ha)			
	400 or less	400–800	800–1590	1600 or more
	Responses (%)			
2cm accuracy	26	45	85	94
10cm accuracy	42	40	10	0
No GPS	32	15	5	6
Total	**100**	**100**	**100**	**100**

TABLE 8 Use of GPS guidance by proportion of farm income derived from cropping

Use of GPS guidance	Proportion of farm income derived from cropping (%)			
	100	75–99	50–74	<50
	Responses (%)			
2cm	86	67	41	31
10cm	14	22	29	38
No GPS	0	11	29	31
Total	**100**	**100**	**99***	**100**

* This column does not add to 100% due to rounding of percentages to whole numbers.

TABLE 9 Precision agriculture technology adoption by cropping area

PA type	Cropping area (ha)			
	400 or less	400–800	800–1590	1600 or more
	Responses (%)			
Yield monitoring	14	29	45	88
Electro magnetic surveying	5	41	55	65
Variable rate technology	10	12	20	53

TABLE 10 Precision agriculture technology adoption by proportion of farm income derived from cropping

PA type	Proportion of farm income derived from cropping (%)			
	100	75–99	50–74	<50
	Responses (%)			
Yield monitoring	61	50	29	8
Electro magnetic surveying	61	44	24	8
Variable rate technology	25	39	18	0

Performance of first wheat after canola under no-till full stubble retention (NTSR) using different drill openers and row spacing at Coreen

Nick Poole[1], Tracey Wylie[1] and John Seidel[2]
[1] Foundation for Arable Research, New Zealand in conjunction with Riverine Plains Inc
[2] Agricultural Research Services

Key points

- In the 2012 wheat after canola trial, moving from a narrow row spacing (22.5cm) to a 30cm spacing reduced yield by 9%. Moving from 22.5cm to the widest (37.5cm) row spacing reduced yield by 11%.
- In a season where yields averaged about 3t/ha overall (based on a GSR of 196mm plus 85mm stored soil moisture), increasing row spacing beyond 22.5cm significantly reduced yield.
- During 2009, in the same rotation position on the same trial site, there was no difference in yield between the 22.5cm and 30cm row spacings (based on 2.5t/ha average yields), although the 37.5cm row spacing still yielded significantly less.
- The narrowest row spacing (22.5cm) produced more biomass than the wider row spacing and converted this biomass into higher grain yield, giving a harvest index (HI) of 29%.
- There was no difference in crop establishment, biomass or grain yield due to type of drill opener used (tine versus disc).
- The narrow row spacing was estimated to result in better water use efficiency (WUE) than the wider spacing, despite having a lower HI. During 2009, the advantage of higher biomass in the 22.5cm row spacing was equally counterbalanced by the higher HI in the 30cm row spacing. During 2012, this was not the case and the higher biomass of the narrower row spacing had the greater impact on grain yields.

Location: Coreen, NSW

Rainfall:
Annual: 475.5mm (2012)
GSR: 196mm (Apr–Oct)
Stored moisture: Estimated 85mm (estimated at 35% fallow efficiency of 242mm)

Soil:
Type: Loam clay
pH (H_2O): 5.8 (2011)
pH ($CaCl_2$): 5.3 (2011)
Colwell P: 86mg/kg (2011)
Deep soil nitrogen: 46 kg/ha (2011)

Sowing information:
Variety: Spitfire sown at 85kg/ha
Sowing date: 17 May 2012
Sowing rate: 85kg/ha
Fertiliser: 85kg/ha MAP + Intake
Sowing equipment: Janke tine with Janke presswheel. Single disc opener.
Treatments: Establishment method x row spacing

Row spacing: 22.5cm, 30cm, 37.5cm

Paddock history:
2011 — canola
2010 — wheat
2009 — wheat

Plot size: 44m x 3m

Replicates: 4 (disc) 8 (tine)

Overall goal

Improved water use efficiency (WUE) in no-till cropping and stubble retention systems in spatially and temporally variable conditions in the Riverine Plains.

Aim

The aim of this trial was to evaluate the performance of different drill openers at a range of row spacings in the first wheat crop after the break crop (canola).

Method

A replicated experiment was established to test the effect of a range of drill openers and row spacings on the first wheat crop after the break crop of canola as part of a four-year cropping rotation trial. The 2012 wheat crop was the fourth successive crop superimposed on the original no-till stubble retention trial site.

- 2008 — canola (farm crop)
- 2009 — wheat
- 2010 — wheat
- 2011 — canola
- **2012 — wheat**

Crop stubble from the previous year's canola crop trial was chopped and spread at right angles to the direction of plots.

Results

Crop establishment

Wheat was established into the stubble of the previous 2t/ha canola crop. Plant establishment assessed 26 and 40 days after sowing showed that the 22.5cm row spacing had significantly superior plant establishment to the 30cm row spacing, which in turn was significantly superior to the 37.5cm row spacing (see Table 1 and Figure 1). There was no statistical difference in plant establishment between the tine and disc openers at either the one-leaf or three-leaf stages (see Figure 2). This trial showed the same significant results as an identical trial carried out on the same site during 2009, following the same break crop (see *Research for the Riverine Plains 2010*, p14).

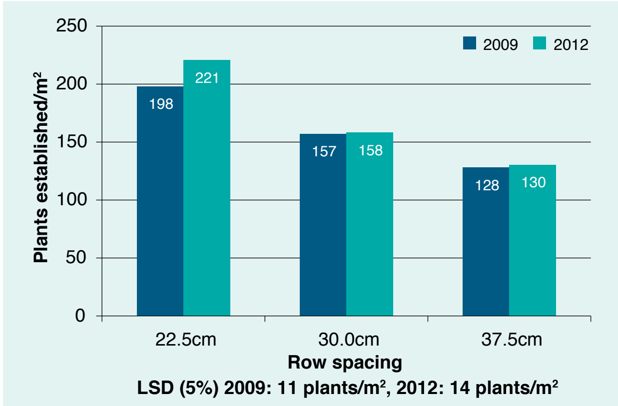

FIGURE 1 Influence of row spacing on plant establishment at the three-leaves-unfolded stage (GS13) in the first wheat following canola in 2009 and 2012 established on the same site*

* Mean of both drill openers

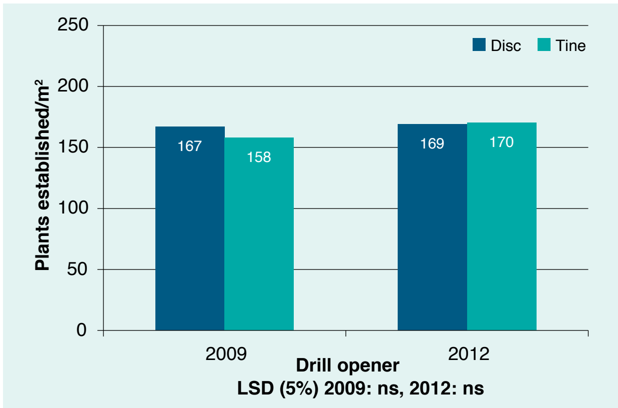

FIGURE 2 Influence of drill opener on plant establishment at the three-leaves-unfolded stage (GS13) in the first wheat following canola in 2009 and 2012 established on the same site*

* Mean of three row spacings

TABLE 1 Plant establishment at the one-leaf-unfolded stage (GS11) and the three-leaves-unfolded stage (GS13) 26 and 40 days after sowing

Row spacing (cm)	Drill opener Plant establishment (plants/m²)					
	12 June 2012			26 June 2012		
	Disc	Tine	Mean	Disc	Tine	Mean
22.5	183	186	185	219	222	221
30	128	141	135	156	161	158
37.5	120	103	112	133	129	131
Mean	144	144		169	171	
LSD [row spacing]	11			14		
LSD [drill opener]	9			12		
LSD [opener x row]	15			20		
Interactions — drill opener x row spacing	*			ns		

* Significant interaction between drill opener and row spacing

At the one-leaf-stage (GS11), there was a significant interaction between row spacing and drill opener, indicating the tine opener had significantly lower plant establishment than the disc at the 37.5cm spacing. The disc did not reduce establishment when comparing the 30cm and 37.5cm row spacings (see Figure 3).

There was no significant interaction ($P<0.05$) between row spacing and drill opener at the three-leaves-unfolded stage (GS13), with little difference in establishment as a result of opener type.

Dry matter production

i) Row spacing

Dry matter (DM) production was significantly higher at the 22.5cm spacing than the 30cm spacing, which in turn was significantly higher than the 37.5cm spacing until the harvest assessment (GS99). When DM was assessed at harvest, the narrow row spacing (22.5cm) had produced significantly more DM than the widest row spacing (37.5cm), however neither treatment was significantly different to the 30cm row spacing (see Figure 4). This trend is similar to that seen in the first wheat after canola at this site in 2009 when the 22.5cm row spacing produced significantly more DM than the 37.5cm throughout the growing season.

During 2009, the 30cm row spacing fell non-significantly between the narrow and widest row until harvest.

ii) Drill opener

There were no significant differences generated in DM production during 2012 as a result of drill opener type (see Figure 5). This is different to 2009 when the disc opener produced significantly more DM throughout the growing season than the tine opener.

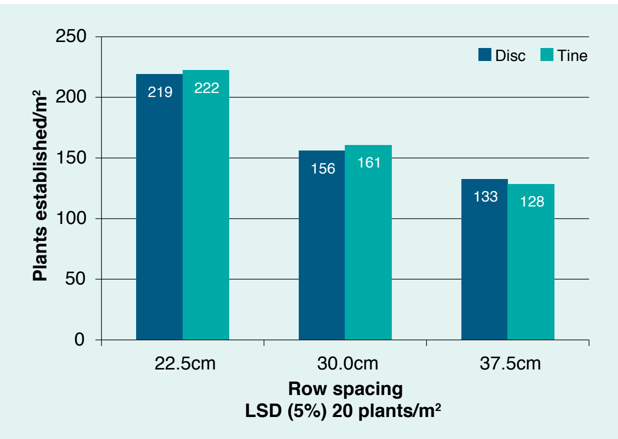

FIGURE 3 Influence of row spacing and drill opener method on plant establishment, at the three-leaves-unfolded stage (GS13)

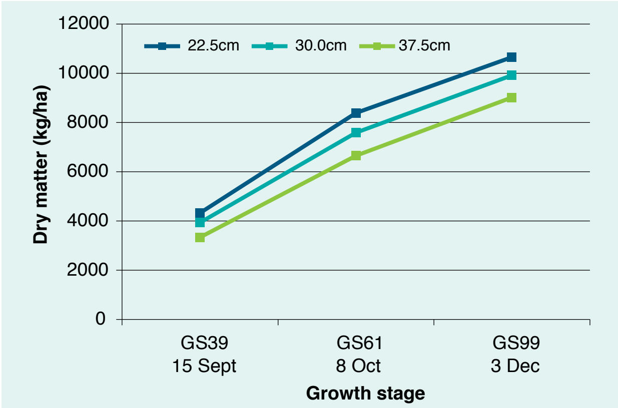

FIGURE 4 Influence of row spacing on dry matter production*

* Mean of both drill openers (15 September – 3 December 2012)

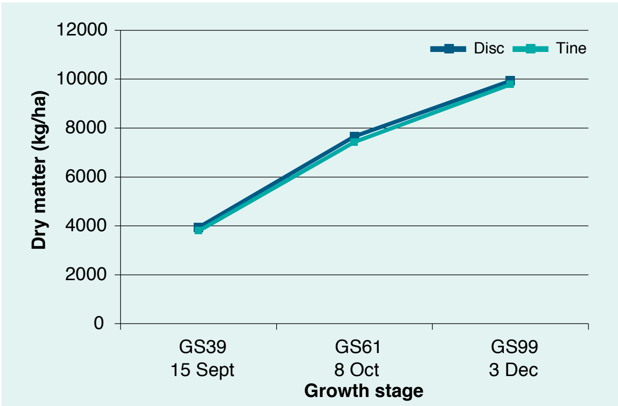

FIGURE 5 Influence of drill opener on dry matter production*

* Mean of three row spacings (15 September – 3 December 2012)

There was no significant interaction between the effect of row spacing and drill opener on DM production at harvest (see Figure 6) or throughout the season.

Crop structure

At the 22.5cm row spacing there were significantly more plants, tillers and heads/m^2 produced than with the crops established at 30cm row spacing.

The 37.5cm row spacing produced significantly fewer plants and tillers/m^2 than the 30cm spacing. However, due to the lower tiller mortality, the difference in heads/m^2 was not significant between the two wider row spacings (see Figure 7).

The wider row spacing produced more tillers/plant by the start of stem elongation (the 22.5cm spacing produced 2.66 tillers/plant compared with 2.93 tillers/plant for 30cm spacing and 3.04 tillers/plant for the 37.5cm spacing). However, the narrow row spacing produced more tillers per unit area, but suffered higher tiller mortality between the start of stem elongation and maturity (about 25% at 22.5cm row spacing and just less than 10% at 37.5cm).

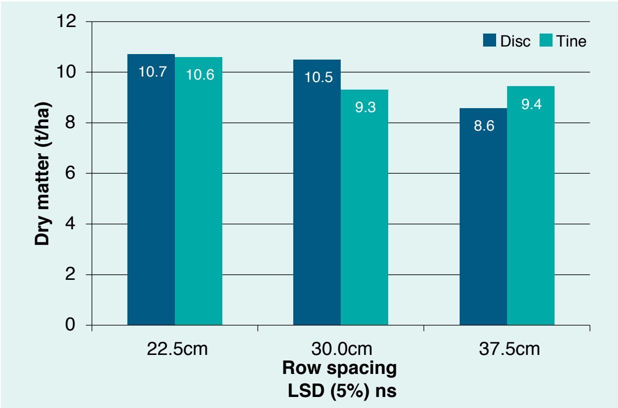

FIGURE 6 Influence of row spacing and drill opener on dry matter production at harvest

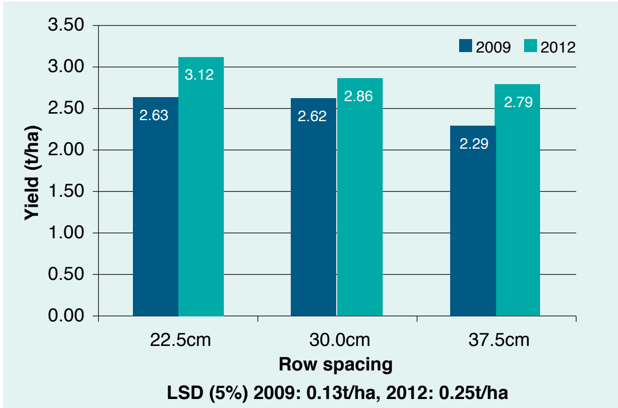

FIGURE 8 Influence of row spacing on yield*

* Mean of both drill openers

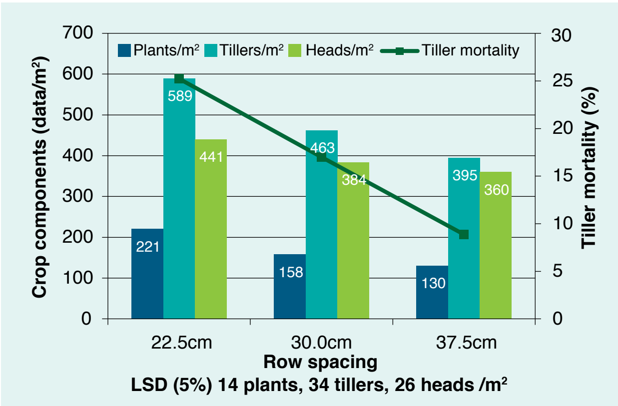

FIGURE 7 Influence of row spacing on crop structure*

* Mean of both drill openers

Yield

i) Yield

The trial had an average yield of 2.92t/ha, which was 0.38t/ha more than the first wheat crop following canola grown on the site during 2009. During 2009, the crop had a growing season rainfall (GSR) of 234mm with little or no stored soil moisture (compared with 196mm GSR during 2012 with 85mm stored soil moisture).

During 2009, with less available soil moisture and lower yields, there was no significant yield difference between the 22.5cm and 30cm row spacings. However, during 2012, with an average yield of about 3t/ha, there was a significant advantage to the narrowest row spacing (see Figure 8).

During 2012, there was a yield penalty of 9% associated with moving from the 22.5cm spacing to the 30cm spacing. There was no significant yield difference between the 30cm and 37.5cm spacings.

The reduction in yield caused by widening row spacing from 22.5cm to 37.5cm was about 11% during 2012. In the first wheat trial sown at the same time in the same paddock in 2009, there was no yield penalty from increasing from 22.5cm to 30cm, but a 13% yield reduction from increasing row spacing from 30cm to 37.5cm.

There was no yield difference generated in the trial as a result of the drill opener used in 2012 (see Figure 9). This result is contrary to the results recorded at the same site in 2009 when the disc opener produced significantly more DM throughout the season and had significantly higher yields.

There was no significant interaction between row spacing and drill opener on the yields obtained in the trial (see Figure 10).

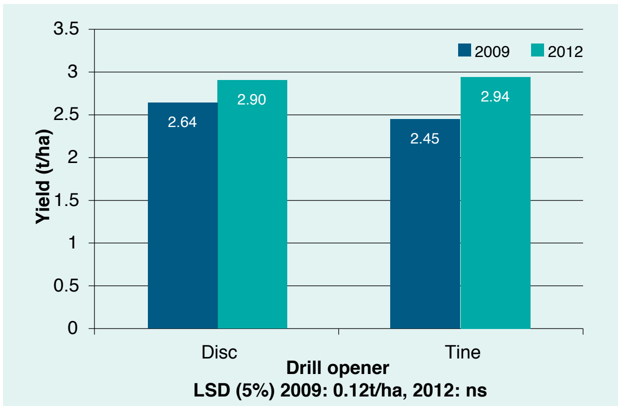

FIGURE 9 Influence of drill opener on yield*

* Mean of three row spacings

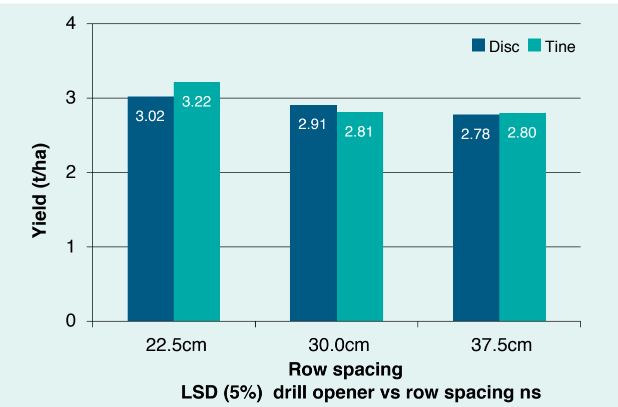

FIGURE 10 Influence of row spacing and drill opener on yield

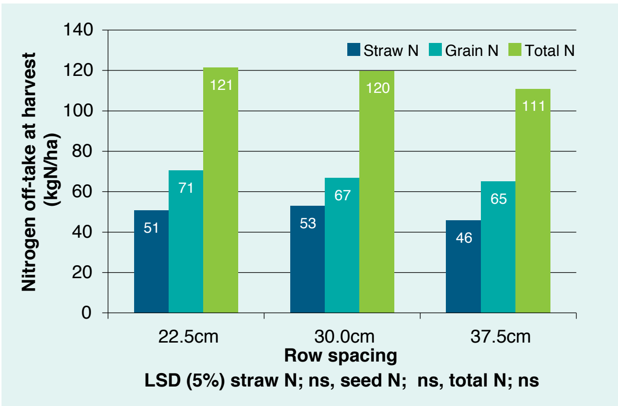

FIGURE 11 Influence of row spacing on nitrogen off-take at harvest*

* Mean of both drill openers

ii) Protein content and grain quality

There were no significant differences in grain protein content, thousand seed weight, test weight or screenings generated in the trial as a result of row spacing or drill opener.

iii) Nitrogen off-take

Row spacing did not significantly influence nitrogen off-take (see Figure 11). However, the type of drill opener used caused a significant (p 0.0155) difference in nitrogen off-take, with more nitrogen removed in the straw of the tine opener treatment — a difference that carried through to a greater overall total nitrogen off-take (data not shown).

Observations and comments

It was estimated that the narrow row spacing produced the best overall WUE (see Table 2). Unlike wheat-on-wheat trials in this research project, the differences in harvest index (HI) were relatively small (28.8–30.9%), indicating that significantly higher biomass at harvest translated to significantly higher grain yields.

All other trends in WUE were similar to those observed in previous seasons (i.e. there is estimated to be more unproductive water in the wider row spacing, however with improved efficiency of water use by the plant which is then converted into grain). This is measured and reported as transpiration efficiency (TE).



TABLE 2 Biomass at harvest, yield, harvest index (HI), water use efficiency (WUE), transpiration, evaporation/drainage and transpiration efficiency (TE)*

Row spacing (cm)	Biomass (kg/ha)	Yield (kg/ha)	HI (%)	WUE[1] (kg/mm)	Transpiration[2] (mm)	Unproductive water[3] (mm)	TE[4] (kg/mm)
22.5	10651	3118	29.3	11.1	194	87	16.1
30	9914	2860	28.8	10.2	180	100	15.9
37.5	9010	2788	30.9	9.9	164	117	17.0

[1] Based on 196mm of GSR (April – October) + 35% fallow efficiency (85mm) for January – March rainfall (total GSR + stored = 281mm) with no soil evaporation term included and assuming no drainage in periods of excessive rainfall.
[2] Transpiration through the plant based on a maximum 55kg harvest biomass/ha.mm transpired.
[3] Unproductive water (evaporation, drainage and water left unused at harvest) is the difference between transpiration through the plant and GSR (mm) + stored water at sowing.
[4] Transpiration efficiency based on kg/ha grain produced per mm of water transpired through the plant.
* Mean of both openers

Sponsors

This trial was carried out as part of the Riverine Plains Inc GRDC-funded project *Improved WUE in no-till cropping and stubble retention systems in spatially and temporally variable conditions in the Riverine Plains* (RP100007).

Thanks go to farmer co-operators, the Hanrahan family and John Seidel as trial manager.

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Performance of second wheat (wheat on wheat) after canola under no-till full stubble retention (NTSR) using different drill openers and row spacings at Bungeet

Nick Poole[1], Tracey Wylie[1] and John Seidel[2]
in conjunction with Riverine Plains Inc
[1] Foundation for Arable Research, Australia
[2] Agricultural Research Services

Key points

- Gauntlet wheat sown as the second wheat crop after canola yielded between 3.84–4.44t/ha with 232mm of growing season rainfall (Apr-Oct) and an estimated 118mm of stored water at sowing (total 350mm).
- Moving from a narrow row spacing (22.5cm) to 30cm and 37.5cm row spacings reduced yield by 13% and 11% respectively in the 2012 season. In 2011, moving from a 22.5cm spacing to 30cm and 37.5cm spacings reduced yield by 4% and 10% respectively for the second wheat trial grown in the same paddock.
- It was estimated that the narrow row spacing (22.5cm) resulted in better water use efficiency (WUE) than the widest spacing (37.5cm), despite having a lower harvest index (44% vs 47%) than the widest rows.
- Wider rows produced relatively more grain for the crop biomass produced, but the biomass produced was significantly lower overall. This indicates that water available to the crop was not used as effectively as in the narrower rows.

Location: Bungeet, Victoria

Rainfall:
- Annual: 621mm (2012)
- GSR: 232mm (Apr–Oct)
- Stored moisture: Estimated 118mm (estimated at 35% fallow efficiency)

Soil:
- Type: Loam over clay, Wattville No.205
- pH (H_2O): 6.0 (2011)
- pH ($CaCl_2$): 5.5 (2011)
- Colwell P: 65mg/kg (2011)
- Deep soil nitrogen: 55kg/ha (2011)

Sowing information:
- Variety: Gauntlet
- Sowing date: 22 May 2012
- Sowing rate: 85kg/ha
- Fertiliser: 85kg/ha MAP + Intake
- Sowing equipment: Janke tine with Janke presswheel. Single disc opener.
- Treatments: Establishment method x row spacing

Row spacing: 22.5cm, 30cm, 37.5cm

Paddock history:
- 2011 — wheat
- 2010 — canola
- 2009 — wheat

Plot size: 44m x 3m

Replicates: 4 (disc) 8 (tine)

Overall goal

Improved water use efficiency (WUE) in no-till cropping and stubble retention systems in spatially and temporally variable conditions in the Riverine Plains

Aim

The aim of this trial was to evaluate the performance of different drill openers at a range of row spacings in the second wheat crop (wheat on wheat) after canola.

Method

A replicated experiment was established to test the effect of a range of drill openers and row spacings on a second wheat crop after a break crop of canola. The trial is part of a four-year cropping rotation trial carried out on



the same trial site at Bungeet, Victoria. Two trials were established in two successive seasons (2009 and 2010) to give two time replicates for the rotation. Second wheat established during 2012 was the fourth successive crop superimposed on the original plots laid down during 2009 (time replicate one), with treatments being laid down on the same treatments each season.

Time replicate one

- 2008 wheat (farm crop)
- 2009 wheat
- 2010 canola
- 2011 wheat
- **2012 wheat**

Time replicate two

- 2008 wheat (farm crop)
- 2009 faba beans (farm crop)
- 2010 wheat
- 2011 wheat
- **2012 canola**

Crop stubble from the previous year's first wheat crop trial was chopped and spread at right angles to the direction of plots.

Results

Results from the 2012 second wheat crop (from the time replicate 1 trial) are reported below.

Crop establishment

The row spacing and drill opener interaction created significant differences in crop establishment in the second wheat crop (wheat on wheat) after canola. Plant establishment at the 22.5cm row spacing was significantly superior to the 30cm, which in turn was significantly superior to the 37.5cm spacing at both assessment timings (see Table 1 and Figure 1). The result was identical to that observed in the second wheat trial established during 2011 in the same paddock (time replicate two), although with higher overall establishment during 2012.

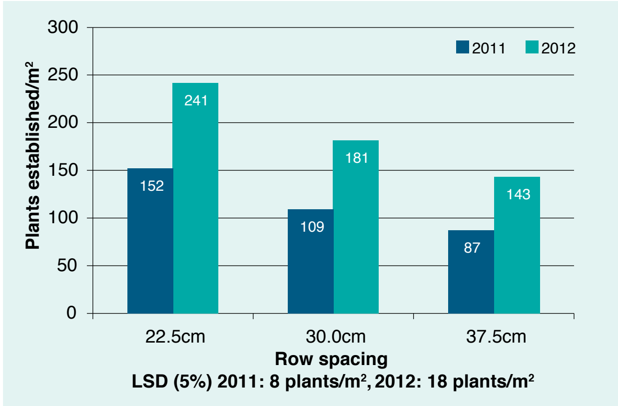

FIGURE 1 Influence of row spacing on plant establishment in the second wheat rotation position during 2011 (time replicate two) and 2012 (time replicate one) assessed at the three-leaves-unfolded stage (GS13)*

* Mean of both drill openers

There was no significant difference generated in crop establishment as a result of drill opener used (see Figure 2). This lack of difference due to drill opener was also observed in the 2011 second wheat crop (time replicate two).

There was a significant interaction ($p=0.03$) between row spacing and drill opener at the one-leaf-unfolded stage (GS11) (see Figure 3), suggesting increasing to wider row spacings has less influence on plant establishment with the disc opener compared with the tine. This interaction was not evident at the three-leaves-unfolded (GS13) assessment. The germination of plants with the disc opener was more protracted than was observed with the tine.

TABLE 1 Plant establishment at one-leaf-unfolded stage (GS11) and two to three-leaves-unfolded stage (GS12–13), 32 and 39 days after sowing

Row spacing (cm)	Drill opener Plant establishment (plants/m²)					
	23 June 2012			30 June 2012		
	Disc	Tine	Mean	Disc	Tine	Mean
22.5	190	223	206	238	245	241
30	166	149	157	191	173	181
37.5	119	129	124	143	144	143
Mean	158	166		190	187	
LSD [row spacing]	15			15		
LSD [drill opener]	18			18		
LSD [opener x row]	25			26		
Interactions — drill opener x row spacing	*			ns		

* Significant interaction between drill opener and row spacing.

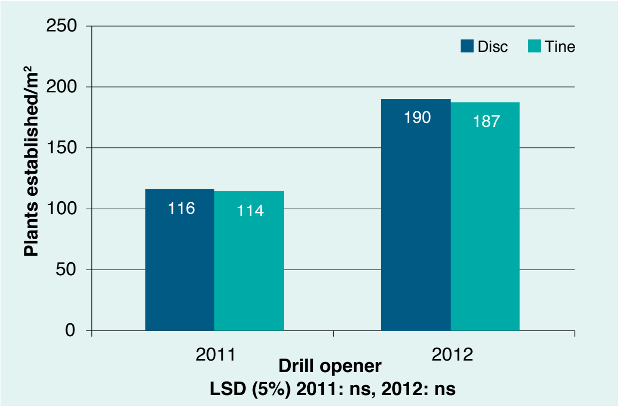

FIGURE 2 Influence of drill opener on plant establishment in second wheat following the break during 2012 and 2011 established on the same site and assessed at the three-leaves-unfolded stage (GS13)*

* Mean of three row spacings

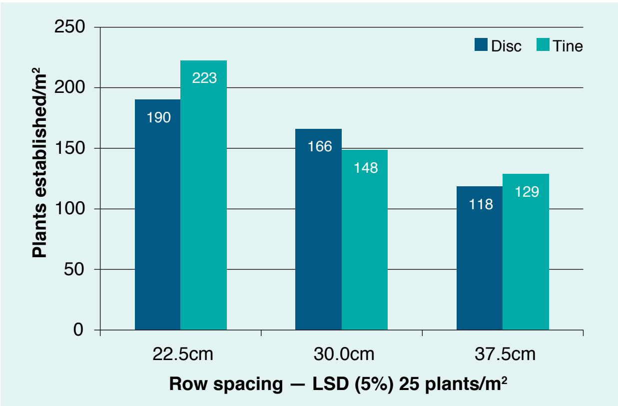

FIGURE 3 Influence of row spacing and drill opener method on plant establishment, at one-leaf-unfolded stage (GS11)

Dry matter production

i) Row spacing

Dry matter (DM) production throughout the growing season was significantly higher at the 22.5cm row spacing than at the 37.5cm spacing. Between the wider row spacings (30cm and 37.5cm), there was no significant difference in DM production at any of the assessment timings. The flowering (GS61) plus 15 day assessment (on 19 October) was the only assessment where the 22.5cm spacing did not produce significantly higher DM than the 30cm row spacing (see Figure 4).

This trend was similar to that observed in the second wheat grown on this site previously. In these previous trials, the 22.5cm row spacing produced significantly more DM throughout the growing season than the widest row spacing (37.5cm). The quantity of DM produced by the 30cm spacing was intermediate between the 22.5cm and 37.5cm results (statistical significance varying between trials).

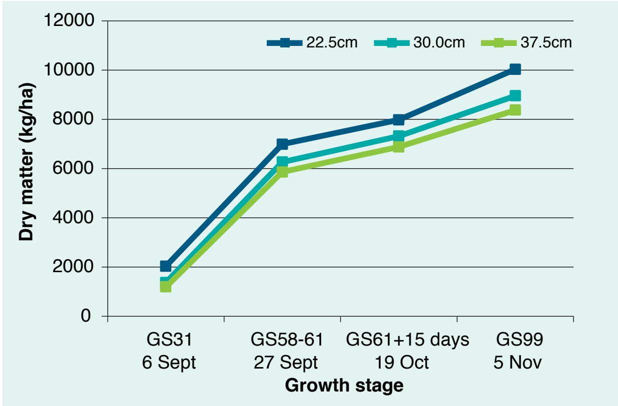

FIGURE 4 Influence of row spacing on dry matter production* in second wheat

* Mean of both drill openers (6 September – 5 November 2012)

ii) Drill opener

During 2012, the disc opener produced significantly (p=0.02) more DM/ha at the first node (GS31) assessment (194kg DM/ha) in early September and again at the harvest assessment (771kg DM/ha), than the tine drill opener (see Figure 5).

The 2011 second wheat trial (time replicate two) showed no influence of drill opener on DM production.

The 2012 trial showed a significant interaction between row spacing and drill opener in DM assessed at crop maturity (GS99) (see Figure 6). This interaction, which was evident in both 2011 and 2012, indicated that moving row spacing from 22.5cm to 30cm significantly reduced DM production with the tine opener, but not the with disc opener. It is unclear why this is the case but it does correlate with the plant establishment results, which were lower with tine opener at the 30cm row spacing.

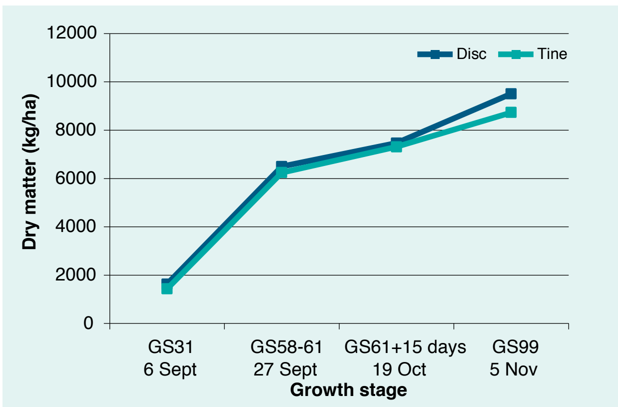

FIGURE 5 Influence of drill opener on dry matter production*

* Mean of three row spacings (6 September – 5 November 2012)

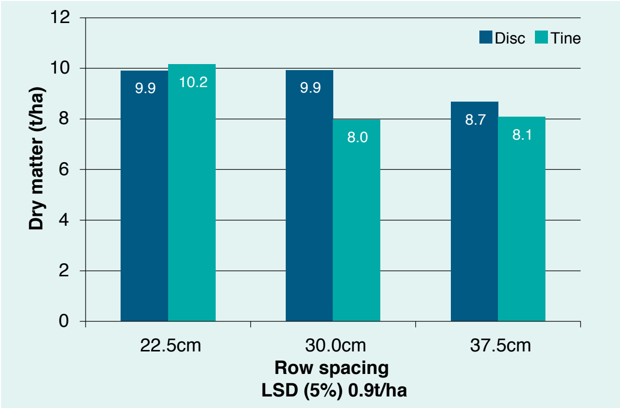

FIGURE 6 Influence of row spacing and drill opener on dry matter production at harvest

Crop structure

At the 22.5cm row spacing there were significantly more plants, tillers and heads/m^2 produced than with the crop established using the 30cm row spacing. In turn, the 30cm row spacing had significantly more plants, tillers and heads/m^2 than the 37.5cm row spacing (see Figure 7).

Interestingly, while there was no significant difference in plant establishment results between the disc and tine opener at establishment, the disc opener produced significantly more tillers and heads/m^2 at harvest than the tine opener (data not shown).

Tiller mortality was greatest at the narrow row spacing (26%), with proportionally fewer tillers forming a head compared with the wider row spacings. Tiller mortality rates were similar to those observed in the 2012 first wheat trial at Coreen. In terms of tiller production per established plant, the differences due to row spacing were relatively small (1.93–2.08 tillers/plant).

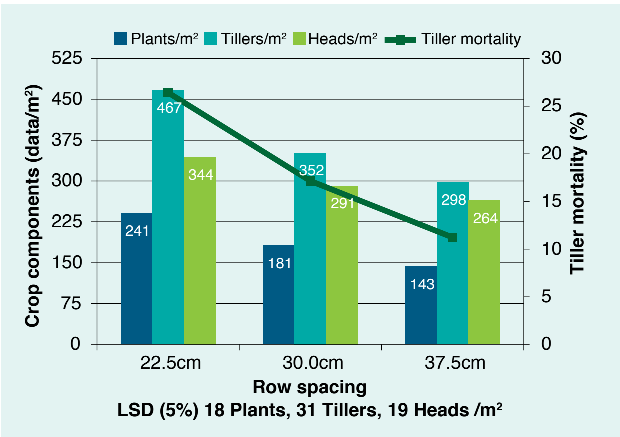

FIGURE 7 Influence of row spacing on crop structure in second wheat*

* Mean of both drill openers

Yield

i) Yield

The 2012 trial had an average yield of 4.08t/ha, which was 0.23t/ha higher than the second wheat crop grown on the site during 2011 (time replicate two). The 2012 trial produced the same result as the 2011 trial, whereby the 22.5cm row spacing significantly out yielded the 37.5cm row spacing. During 2012, the advantage of the 22.5cm spacing was 0.49t/ha (mean of both drill openers) more than the 37.5cm spacing, compared to a yield advantage of 0.39t/ha more than the 37.5cm spacing in 2011.

The principal difference between the 2011 and 2012 results was that the 30cm row spacing was also significantly inferior to the 22.5cm row spacing during 2012 (see Figure 8).

During 2012 there was no yield difference generated in the trial as a result of the drill opener. This was despite the differences in DM production in favour of the disc and the significant difference in ear numbers between the openers observed this season. The same result was also observed in 2011 (see Figure 9).

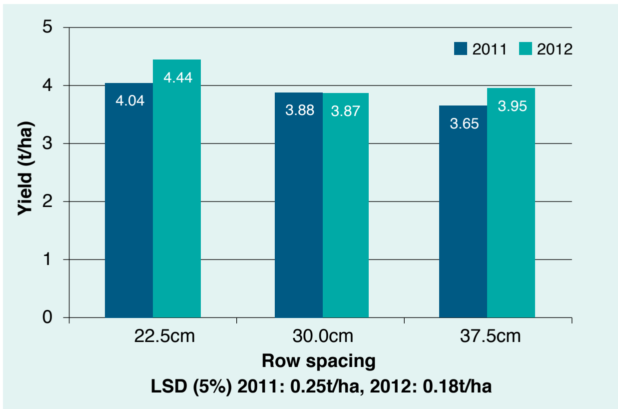

FIGURE 8 Influence of row spacing on yield in second wheat – 2011 and 2012*

* Mean of both drill openers

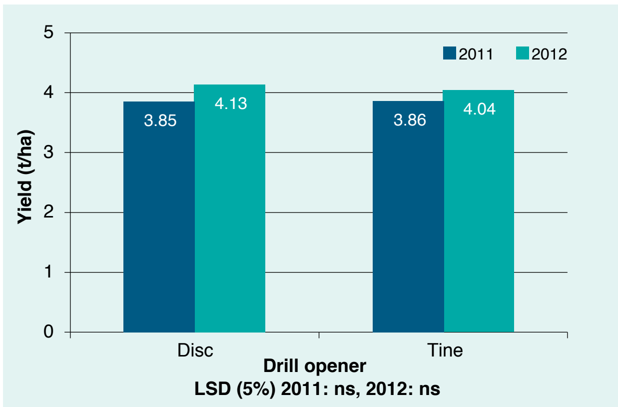

FIGURE 9 Influence of drill opener on yield*

* Mean of three row spacings

There was a significant interaction (p = 0.042) between row spacing and drill opener on the yields observed in the trial (see Figure 10). This indicates that yields from the disc opener were less affected by wider row spacings than the equivalent tine treatments. The disc opener at the widest row spacing yielded significantly more than the tine opener.

Interestingly, green leaf retention data collected at flowering GS65+15 days (19 October) showed the greatest level of greenness retention (on the top three leaves of the canopy) was in the disc-established plots at the 37.5cm row spacing (data not shown). There was a significant interaction between row spacing and disc opener on green leaf retention but only when measured on the last emerged leaf before the flag (Flag-1).

ii) Grain protein content

The crop established at the narrow row spacing (22.5cm) generated the lowest protein content of 9.8%. This was significantly (p=0.02) less than the widest row spacing (37.5cm) at 10.3%. The intermediate row spacing (30cm) had a protein content between the two extremes and was not significantly different to either the widest or the narrowest row spacing.

iii) Nitrogen off-take

Crops established at the 22.5cm row spacing removed significantly more nitrogen in the straw and grain than the widest (37.5cm) row spacing (see Figure 11). Between 16% and 21% of the nitrogen removed at harvest was in the straw and head residue, with the remainder in the grain. There was no significant difference in nitrogen removal between the crops established with narrow and intermediate row spacings or the intermediate and widest row spacings.

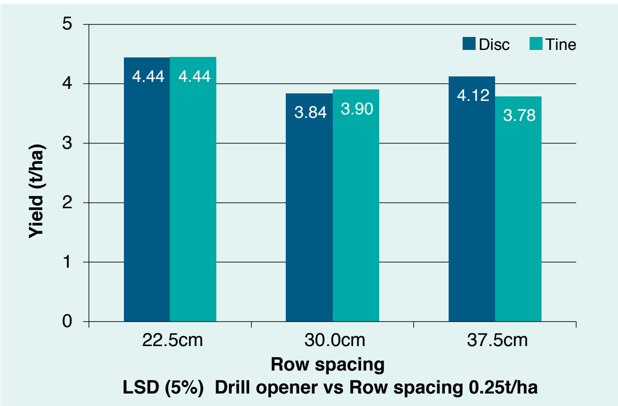

FIGURE 10 Influence of row spacing and drill opener on second wheat yield

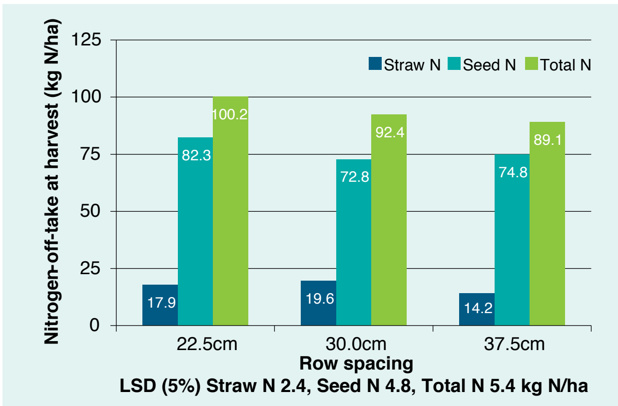

FIGURE 11 Influence of row spacing and drill opener on nitrogen off-take at harvest in second wheat*

* Mean of both drill openers

TABLE 2 Biomass at harvest, yield, harvest index (HI), water use efficiency (WUE), transpiration, evaporation/drainage and transpiration efficiency (TE)*

Row spacing (cm)	Biomass (kg/ha)	Yield (kg/ha)	HI (%)	WUE[1] (kg/mm)	Transpiration[2] (mm)	Unproductive water[3] (mm)	TE[4] (kg/mm)
22.5	10030	4441	44.3	12.7	182	167	24.4
30	8953	3867	43.2	11.1	163	187	23.8
37.5	8372	3952	47.2	11.3	152	198	26.0

[1] Based on 232mm of GSR (April – October) + 35% fallow efficiency (118mm) for January – March rainfall (total GSR + stored = 350mm) with no soil evaporation term included and assuming no drainage in periods of excessive rainfall.

[2] Transpiration through the plant based on a maximum 55kg harvest biomass/ha.mm transpired.

[3] Unproductive water (evaporation, drainage and water left unused at harvest) is the difference between transpiration through the plant and GSR (mm) + stored water at sowing.

[4] Transpiration efficiency based on kg/ha grain produced per mm of water transpired through the plant.

* Mean of both openers



Observations and comments

Estimating WUE from DM production at harvest showed that the narrow row spacing (22.5cm) had better overall WUE than the other spacings. The narrow spacing had the lowest level of unproductive water (water lost through evaporation, drainage and/or water left unused at harvest). However, the transpiration efficiency (grain produced per millmetre of water going through the plant) was lower with the narrow and middle spacings because less of the biomass produced was converted to grain compared with the widest (37.5cm) rows (i.e. the narrow and intermediate rows had a lower harvest index than the widest rows). The advantage of wider rows in lower harvest index and higher transpiration efficiency were however outweighed by greater use of the available soil water with the narrow rows (see Table 2).

Sponsors

This trial was carried out as part of the Riverine Plains Inc GRDC-funded project *Improved WUE in no-till cropping and stubble retention systems in spatially and temporally variable conditions in the Riverine Plains* (RP100007).

Thanks go to farmer co-operator, John Alexander and John Seidel as trial manager.

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Performance of wheat under no-till full stubble retention (NTSR) using in-crop nitrogen, plant population and row spacing at Yarrawonga

Nick Poole[1], Tracey Wylie[1] and John Seidel[2]
in conjunction with Riverine Plains Inc
[1] Foundation for Arable Research, Australia
[2] Agricultural Research Services

Key points

- Plant establishment was significantly higher at greater target plant populations and narrower row spacings. Nitrogen (N) applied in the seedbed did not affect plant establishment.
- Nitrogen applied in the seedbed generated the largest canopy and the highest yields, however the harvest indices (HI) of the first node GS30–31 application and split nitrogen timing were higher than those of the seedbed application and nil nitrogen control. The greatest yield response to nitrogen was seen with the application of 100kg N/ha, which also generated significantly higher grain protein content.
- The greatest water use efficiency (WUE) was achieved with the narrow row spacing (11.2kg/mm) or where fertiliser was applied at sowing (11.9kg/mm seedbed, 11.5kg/mm split timing).

Location: Yarrawonga, Victoria

Rainfall:
Annual: 621mm
GSR: 206mm (Apr – Oct)
Stored moisture: 127mm (estimated at 35% fallow efficiency)

Sowing information:
Variety: Gauntlet
Sowing date: 21 May 2012
Sowing rate: 100–200 plants/m^2 (target)
Fertiliser: 170kg/ha Superfect
Sowing equipment: Janke tine with Janke presswheel
Treatments: Row spacing x plant population x nitrogen fertiliser rate and timing

Row spacing: 22.5cm and 37.5cm

Paddock history:
2011 — canola
2010 — wheat
2005–2009 — pasture

Plot size: 16m x 2m

Replicates: 4

Overall goal

Improved water use efficiency (WUE) in no-till cropping and stubble retention systems in spatially and temporally variable conditions in the Riverine Plains.

Aim

The aim of this trial was to evaluate the performance of in-crop nitrogen (N), plant population and row spacing interaction in a no-till full stubble retention scenario.

Method

A replicated experiment was established to test the effect of four nitrogen timing strategies across four combinations of row spacing (22.5cm and 37.5cm) and target plant populations (100 plants/m^2 and 200 plants/m^2).

A further four nitrogen strategies (rate and timing) were applied to additional plots established at a 22.5cm row spacing and target plant population of 200 plants/m^2 only.

Stubble retention across the site was minimal in this year of the trial.

Results

Crop establishment

Plant establishment was significantly different as a result of target plant population and row spacing. The 22.5cm row spacing produced significantly more plants/m^2 than the 37.5cm spacing.

Target plant populations were exceeded at both the high and low sowing rates; the 100 plants/m^2 target population established an average of 144 plants/m^2 and the 200 plants/m^2 target population established an average population of 246 plants/m^2.

There was a significant interaction between row spacing and plant population — as the row spacing widened at both the high and low plant populations, the establishment was lowered (see Table 1).

Nitrogen application in the seedbed did not result in a significant difference in plant establishment regardless of rate of nitrogen applied (25 and 50kg N/ha), when averaged across the two target plant populations and two sowing rates.

Nitrogen application (0, 25, 50, 100kg N/ha) made at sowing to the 22.5cm row spacing sown at a target population of 200 plants/m^2 showed no significant difference generated between the eight nitrogen programs applied or among just those with nitrogen at establishment (see Figure 1).

Dry matter production

i) Row spacing

Crop establishment at the narrower row spacing produced significantly more dry matter per hectare (DM/ha) than crop established at the wider row spacing until the start of flowering (GS61).

From flowering through to harvest there was no difference in DM production as a result of row spacing (see Figure 2).

ii) Plant population

Targeting a higher plant population at establishment led to more DM production through to flag leaf emergence (GS39). From flag leaf emergence through to harvest (GS99) there was no significant difference between the two targeted plant populations, although the higher plant population had a marginal DM advantage (see Figure 3).

iii) Nitrogen application; timing and rate

Dry matter differences generated as a result of nitrogen application were not significant at the first assessment at the main shoot and two tillers stage (GS22). From the first node (GS30) assessment through to harvest there was an advantage to the crop that had received 50kg N/ha in the seedbed. This crop also produced significantly more DM than the untreated crop at all assessment timings post GS22 (see Figure 4).

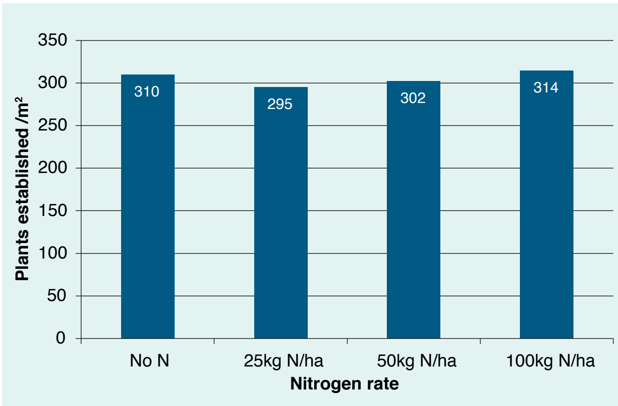

FIGURE 1 Influence of nitrogen application at sowing on plant establishment at a targeted plant population of 200 plants/m^2 sowing in 22.5cm row spacings

TABLE 1 Plant establishment at the three-leaves-unfolded stage (GS13) 40 days after sowing

Nitrogen (N) treatment	Plant establishment (plants/m^2)					
	100 plant/m^2			200 plants/m^2		
Row spacing (cm)	22.5	37.5	Mean	22.5	37.5	Mean
No N	178	110	**144**	310	179	**245**
50kg/ha N seedbed	183	100	**142**	302	180	**241**
50kg/ha N GS30–31	189	102	**146**	312	186	**249**
50:50 Seedbed GS30–31 split	184	104	**144**	313	185	**249**
Mean	**184**	**104**	**144**	**309**	**183**	**246**
LSD [plant population]	10					
LSD [row spacing]	10					
LSD [nitrogen treatment]	15					
LSD [pop^n x row spacing]	15					
LSD [Pop^n x row x N treatment]	30					

At the time of assessment the GS31 N application had not been applied.
Pop^n – Plant population

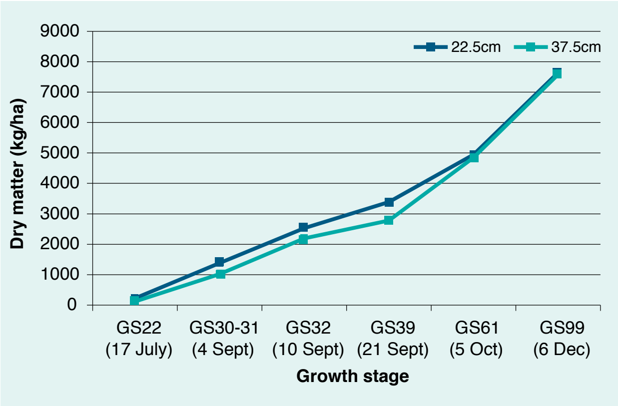

FIGURE 2 Influence of row spacing on DM production*

* Mean of two plant populations and four nitrogen strategies (17 July – 6 December 2012)

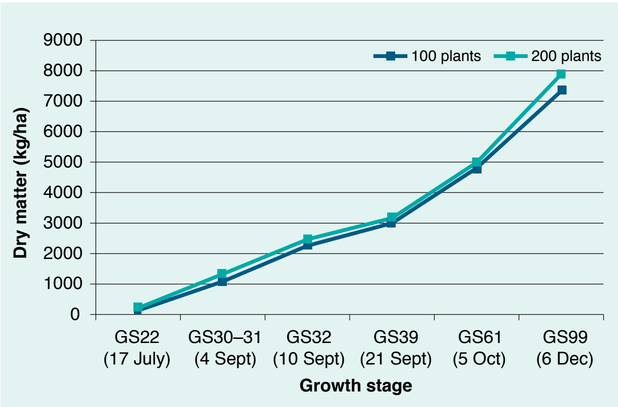

FIGURE 3 Influence of target plant population on dry matter production*

* Mean of two row spacings and four nitrogen strategies (17 July – 6 December 2012)

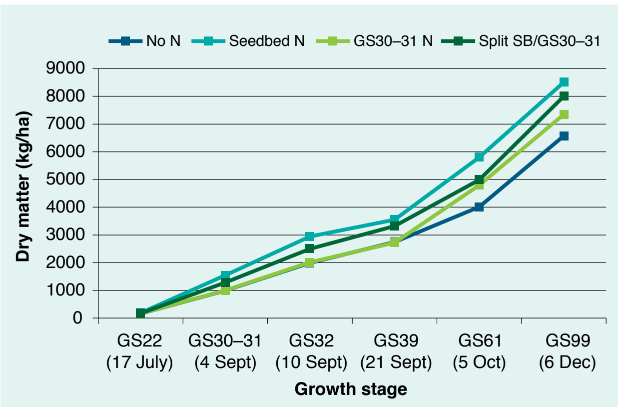

FIGURE 4 Influence of 50kg N/ha applied in the seedbed at GS30–31 and 50:50 split between seedbed and GS30–31 on dry matter production*

* Mean of 2 row spacings and two target plant populations (17 July – 6 December 2012)

At the flag-leaf-fully-emerged (GS39) assessment there was still no significant difference between the untreated crop and the crop that had 50kg N/ha applied at GS30–31.

At the start of flowering (GS61), the effects of the nitrogen application at GS30–31 were evident, with the untreated plots producing significantly less DM than those that received 50kg N/ha at GS30–31 or 50kg N/ha split 50:50 between seedbed and GS30–31. These treatments in turn produced less DM than the plots that received 50kg N/ha in the seedbed.

The harvest DM measurements showed the greatest quantity of DM was produced where the full rate of nitrogen was applied in the seedbed. The quantities of DM produced by the split timing treatment were not significantly different at harvest to either the 50kg N/ha seedbed treatment or the 50kg N/ha applied at GS30–31 treatment.

The untreated plot had the least DM at harvest although it was not significantly inferior to the GS30–31 application.

For the crop established at the 22.5cm spacing with a target plant population of 200 plants/m^2, when the average of three rates (25, 50 and 100kg N/ha) were considered for all assessment timings, there was a significant advantage in DM production as a result of nitrogen application in the seedbed compared with the GS30–31 treatment (see Figure 5).

The rate of nitrogen applied (when averaged across the seedbed treatment and the GS30–31 treatment) generated significant differences in DM production.

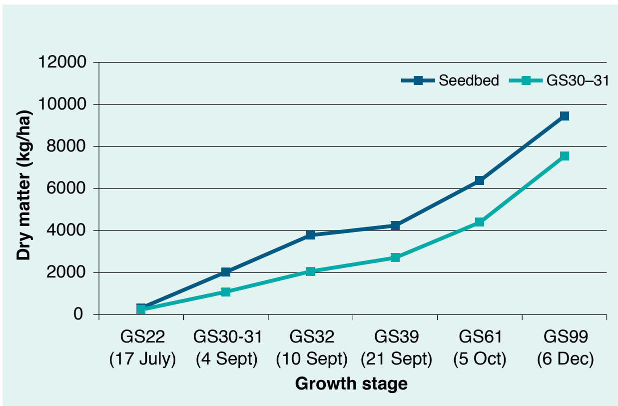

FIGURE 5 Influence of nitrogen timing on dry matter production when sown at a 22.5cm row spacing at a target plant population of 200 plants/m^2*

* Mean of three rates applied (17 July – 6 December 2012)

These differences were not evident until the GS30–31 assessment where the 100kg N/ha applied treatment had significantly increased DM production compared with the 50kg N/ha treatment, which in turn was significantly greater than the 25kg N/ha treatment.

The same trend was evident at the GS39 assessment (see Figure 6).

At the start of flowering (GS61) the 100kg N/ha treatment retained a significant advantage only over the 25kg N/ha treatment.

By harvest, there was no significant differences between treatments in terms of DM production as a result of nitrogen application (see Figure 7).

When compared with the untreated control, the 100kg N/ha applied treatment (average of two timings) was the only treatment to produce more DM.

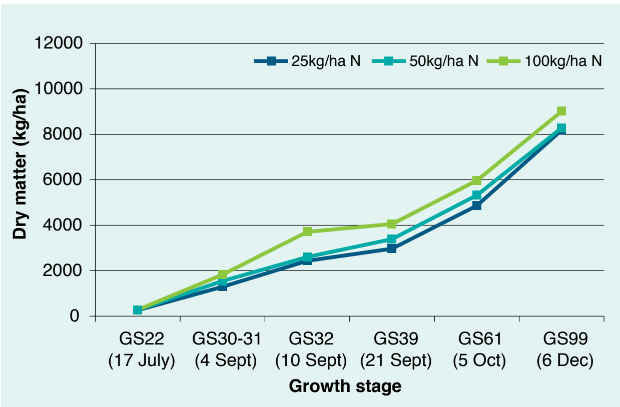

FIGURE 6 Influence of nitrogen rates applied on dry matter production when sown at a 22.5cm row spacing at a target plant population of 200 plants/m²*

* Mean of two application timings (17 July – 6 December 2012)

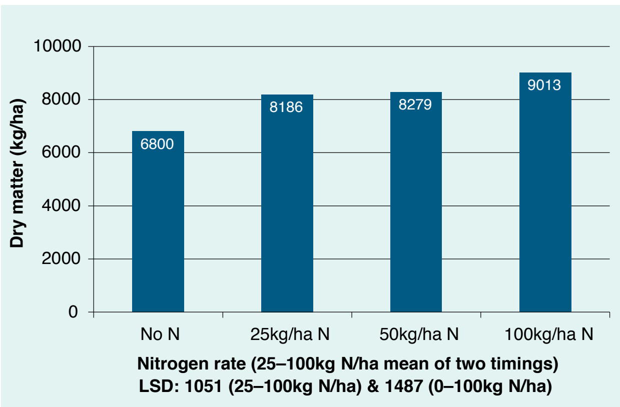

FIGURE 7 Influence of nitrogen rates applied on dry matter production at harvest (6 December 2012) when sown at a 22.5cm row spacing at a target plant population of 200 plants/m²*

* Mean of two application timings

Crop structure

Canopy production was greatest where 50kg N/ha was applied upfront at sowing. Although there were no significant differences between the treatments at establishment, the 50kg N/ha sowing treatment generated significantly more tillers/m² when assessed at GS30–31 than where 25kg N/ha had been applied at sowing (as part of the split treatment). This was still significantly more than the plots that received no nitrogen by GS30–31 (see Figure 8).

This trend followed through to the head counts where the seedbed nitrogen treatment had more heads/m² than both the nil nitrogen treatment and the GS30–31 treatment. There was no significant difference between the nil nitrogen treatment and where the 50kg N/ha had been applied at GS30–31.

Tiller mortality was greatest (33%) when more nitrogen was applied at sowing. Interestingly, the untreated plots also had a tiller mortality rate above 30%.

Yield

i) Yield

There was no difference in yield as a result of targeted plant population. There was however, a significantly higher grain protein content in the lower plant population (8.1% in the 100 plants/m² treatment vs 7.8% in the 200 plants/m² treatment (see Figure 9).

The narrow row spacing significantly out-yielded the wider row spacing. The wider row spacing (with the lower yield) benefited from a lower protein dilution factor and consequently had a significantly higher grain protein content than the narrow row spacing.

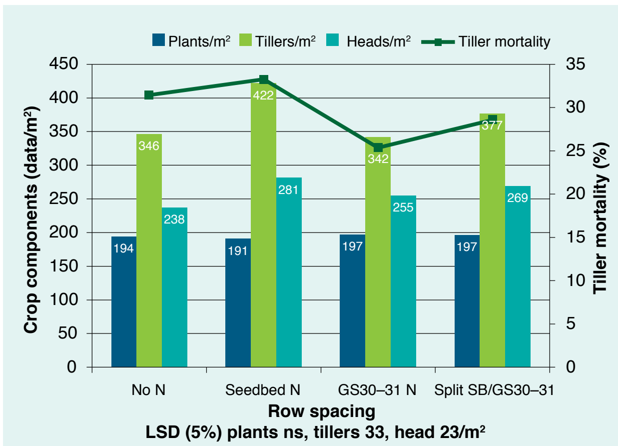

FIGURE 8 Influence of nitrogen application (50kg N/ha) on crop structure (plants 30 June, tillers 4 September, heads 6 December)*

* Mean of two row spacings and two plant populations

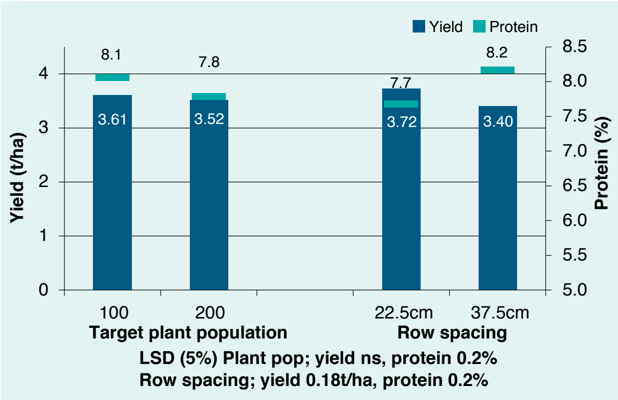

FIGURE 9 Influence of target plant population* and row spacing^ on yield and grain protein

* Mean of two row spacings and four nitrogen timings

^ Mean of two plant populations and four nitrogen timings

Irrespective of timing, nitrogen application of 50kg N/ha significantly increased yield and grain protein content above the untreated plots (average of two row spacings and two target plant populations) (see Figure 10).

Where nitrogen was applied at sowing, regardless of rate, the yield was significantly higher than when nitrogen was applied only at GS30–31. There was no significant difference in grain protein content as a result of nitrogen timing.

When comparing only the effect of nitrogen timing (using one target plant population of 200 plants/m² established at one row spacing of 22.5cm) on yield and grain protein content, yield was found to be significantly higher when nitrogen was applied in the seedbed compared with treatments that received only a GS30–31 application (average of three rates).

The grain had a higher protein content when nitrogen was applied at GS30–31, although not significantly (see Figure 11).

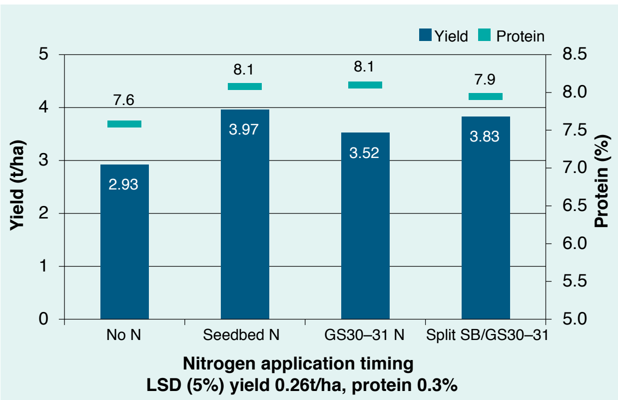

FIGURE 10 Influence of nitrogen application (50kg N/ha) on yield and protein content*

*Mean of two row spacings and two plant populations

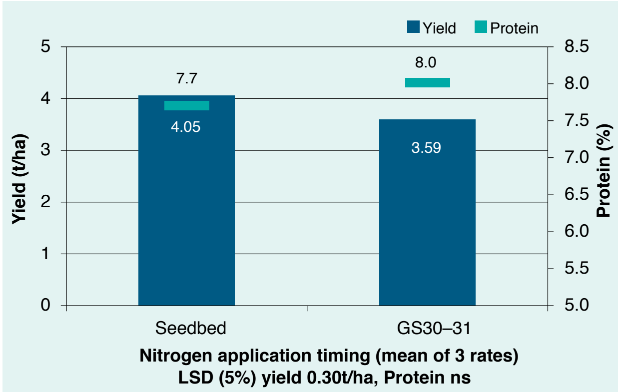

FIGURE 11 Influence of nitrogen timing on yield and grain protein content when sown at a 22.5cm row spacing at a target plant population of 200 plants/m²*

*Means of 3 rates applied

When comparing the influence of differing nitrogen rates with a target plant population of 200 plants/m² and sown at a 22.5cm row spacing, it was found that a significant yield advantage over the untreated control was only achieved with the application of 100kg N/ha (average of two timings).

Neither 25kg N/ha nor 50kg N/ha was sufficient to generate a significant yield advantage over the untreated crop.

The application of 100kg N/ha also generated a significantly higher grain protein content over the untreated plots (see Figure 12).

When comparing the three nitrogen rates (25, 50 and 100kg N/ha), where the two application timings (seedbed and GS30–31) are averaged, the trend was found to be the same, such that the 100kg N/ha treatment produced a significantly higher yield than the two lower rates, between which there was no difference. The same trend was evident within the three treatments for grain protein.

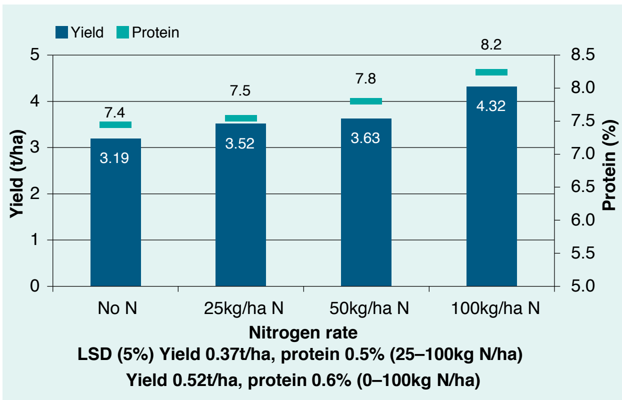

FIGURE 12 Influence of nitrogen rates applied on yield and protein content when sown at a 22.5cm row spacing at a target plant population of 200 plants/m²

* Mean of two application timings

TABLE 2 Biomass at harvest, yield, harvest index (HI), water use efficency (WUE), transpiration, evaporation/drainage and transpiration efficiency (TE)*

	Biomass (kg/ha)	Yield (kg/ha)	HI (%)	WUE[1] (kg/mm)	Transpiration[2] (mm)	Unproductive water[3] (mm)	TE[4] (kg/mm)
Plant pop[n]							
100 (target)	7336	3607	**49**	10.8	133	199	**27.0**
200 (target)	7886	3515	**45**	10.6	143	189	**24.5**
Row spacing (cm)							
22.5	7639	3721	**49**	11.2	139	194	**26.8**
37.5	7582	3400	**45**	10.2	138	195	**24.7**
N treatments (50kg/ha N)							
No N	6574	2926	**45**	8.8	120	213	**24.5**
Seedbed	8514	3966	**47**	11.9	155	178	**25.6**
GS30–31	7349	3523	**48**	10.6	134	199	**26.4**
50:50 split	8007	3829	**48**	11.5	146	187	**26.3**

[1] Based on 206mm of GSR (April – October) + 35% fallow efficiency (127mm) for January – March rainfall (total GSR + stored = 333mm) with no soil evaporation term included and assuming no drainage in periods of excessive rainfall.

[2] Transpiration through the plant based on a maximum 55kg harvest biomass/ha.mm transpired.

[3] Unproductive water (evaporation, drainage and water left unused at harvest) is the difference between transpiration through the plant and GSR (mm) + stored water at sowing.

[4] Transpiration efficiency based on kg/ha grain produced per mm of water transpired through the plant.

Observations and comments

Better harvest indices (% of final crop biomass that was grain) were recorded with the lower target plant population (100 plants/m^2 and the narrow row spacing). These were also the treatments with the greatest transpiration efficiency (TE).

The greatest WUE was achieved with the narrow row spacing (11.2kg/mm) or where fertiliser was applied at sowing (11.9kg/mm seedbed, 11.5kg/mm split timing) (see Table 2).

Sponsors

This trial was carried out as part of the Riverine Plains Inc GRDC-funded project *Improved WUE in no-till cropping and stubble retention systems in spatially and temporally variable conditions in the Riverine Plains* (RP100007).

Thanks go to farmer co-operator, the Inchbold family and John Seidel as trial manager.

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Performance of canola after two years of wheat under no-till full stubble retention (NTSR) using different drill openers and row spacing at Bungeet

Nick Poole[1], Tracey Wylie[1] and John Seidel[2] in conjunction with Riverine Plains Inc
[1] Foundation for Arable Research, Australia
[2] Agricultural Research Services

Key points

- Crusher TT canola yielded between 2.24–2.79 t/ha with 232mm of growing season rainfall (Apr–Oct) and an estimated 118mm of stored available soil moisture (total 350mm).
- All plant populations were high (150–200 plants/m^2) due to an error in calibration, however results produced were similar to previous years, with no significant difference in yield between the narrowest (22.5cm — 2.67t/ha) and widest (37.5cm — 2.75t/ha) row spacings.
- The 30cm spacing yielded significantly lower than both the 22.5cm and the 37.5cm spacings in this trial.
- The disc opener yielded 0.12t/ha more than the tine opener when averaged across row spacings. This yield difference related to higher dry matter production in the disc treatments between pod set and harvest.
- The widest rows (37.5cm) gave the highest harvest index (HI) and estimated water use efficiency (WUE), though the superiority over narrow spacing was relatively small.

Location: Bungeet, Victoria

Rainfall:
Annual: 621mm
GSR: 232mm (April – Oct)
Stored moisture: Estimated 118mm (estimated at 35% fallow efficiency)

Soil:
Type: Loam over clay, Wattville No.205
pH (H_2O): 5.9 (2011)
pH ($CaCl_2$): 5.5 (2011)
Colwell P: 61mg/kg (2011)
Deep soil nitrogen: 64kg/ha (2011)

Sowing information:
Variety: Crusher (TT)
Sowing date: 22 May 2012
Fertiliser: 170kg/ha SuPerfect
Sowing equipment: Janke tine with Janke presswheel. Single disc opener.
Treatments: Establishment method x row spacing

Row spacing: 22.5cm, 30cm, 37.5cm

Paddock history:
2011 — wheat
2010 — wheat
2009 — faba beans (farm crop)

Plot size: 44m x 3m

Replicates: 4 (disc) 8 (tine)

Overall goal

Improved water use efficiency (WUE) in no-till cropping and stubble retention systems in spatially and temporally variable conditions in the Riverine Plains.

Aim

The aim of this trial was to evaluate the performance of different drill openers at a range of row spacings in the canola crop following two years of wheat under full stubble retention.



Method

A replicated experiment was established on the site of time replicate two (see list below) to test the effect of drill opener and row spacing on canola after two years of wheat as part of a three-year cropping rotation trial. The 2012 crop was the third successive crop superimposed on the original no-till stubble retention trial site using time replicate two.

Time replicate one	Time replicate two
• 2008 wheat (farm crop)	2008 wheat (farm crop)
• 2009 wheat	2009 faba beans (farm crop)
• 2010 canola	2010 wheat
• 2011 wheat	2011 wheat
• **2012 wheat**	**2012 canola**

Crop stubble from the previous year's first wheat crop trial was chopped and spread at right angles to the direction of plots.

Results

Results from the 2012 canola crop, from the time replicate two trial are reported below.

Crop establishment

Canola, which followed two years of wheat, was established at the Bungeet site during 2012. Unfortunately the trial was sown at a rate well above the intended sowing rate of 2.5kg/ha.

Despite this error the trial generated significant differences in crop establishment. The 22.5cm row spacing had significantly better establishment than the 30cm row spacing, which in turn was significantly higher than the 37.5cm spacing.

The drill opener also had a significant impact on crop establishment, with the tine opener providing an advantage in crop establishment.

There was no significant interaction between drill opener and row spacing generated in the trial (see Table 1).

Dry matter production

i) Row spacing

The 22.5cm row spacing produced significantly more dry matter/ha (DM/ha) than the 37.5cm spacing throughout the growing season. However by harvest, the significant difference in DM production between the 22.5cm and 37.5cm spacing was no longer evident and the DM content of the 30cm row spacing was significantly inferior to both the 22.5cm and 37.5cm row spacing (P=0.0114). The DM production of the 30cm row spacing only became inferior at harvest; up until pod set it had been identical to the widest row spacing (see Figure 1).

Previous trials in this series on canola carried out at more conventional sowing rates, showed that DM production peaked at pod set during 2009 at 5500kg DM/ha and during 2011 peaked at 10,000kg DM/ha at harvest. In both previous trial years the disc opener has gained the advantage over the tine opener in terms of DM production at pod set.

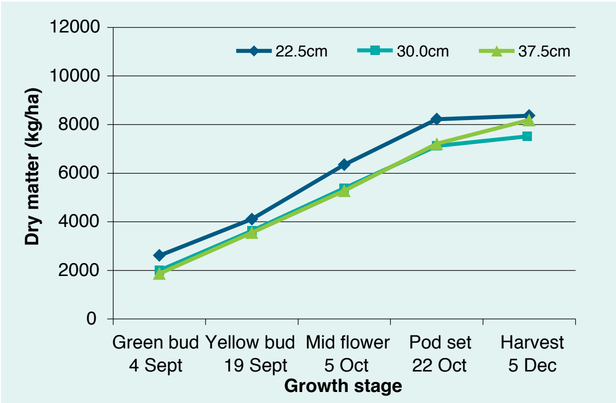

FIGURE 1 Influence of row spacing on dry matter production*

* Mean of both drill openers (4 September – 5 December 2012)

TABLE 1 Canola plant establishment at two-leaves-unfolded growth stage assessed 37 days after sowing at Bungeet

Row spacing (cm)	Drill opener Plant establishment (plants/m²)		
	Disc	Tine	Mean
22.5	215	257	236
30.0	154	170	162
37.5	121	145	133
Mean	**163**	**190**	
LSD [row spacing]	14		
LSD [drill opener]	11		
LSD [disc vs tine]	20		
Interactions — drill opener x row spacing	ns		

ii) Drill opener

There was no significant difference in DM production as a result of drill opener employed until the pod set growth stage. At pod set the disc opener produced significantly more DM/ha than the tine (p=0.0119). The disc opener maintained this significant difference in DM production (p=0.0062) through to the harvest assessment (see Figure 2).

The interaction between drill opener and row spacing in the DM assessment at harvest was nearly significant (p = 0.056), indicating yields from disc openers were less influenced by increasing row width (see Figure 3).

Nitrogen uptake

Nitrogen uptake at green bud was significantly higher at the two narrower row spacings, mainly as a consequence of the higher DM production at the widest (37.5cm) spacing. There was then no difference between the nitrogen uptake of the three spacings until harvest, where the 37.5cm spacing had significantly greater nitrogen uptake than the 22.5cm row spacing. In turn, the 22.5cm spacing had significantly more nitrogen uptake than the 30cm row spacing (p=<0.001) (see Figure 4).

Note that nitrogen content of the crop at pod set was higher than at harvest, a factor most probably linked to loss of larger leaves in the lower canopy before harvest.

Yield

i) Yield

The average yield of the canola trial at Bungeet was 2.59t/ha.

The 30cm spacing was significantly lower yielding than both the 22.5cm and 37.5cm spacings, between which there was no difference.

The disc opener produced higher yields than the tine opener. The 0.12t/ha yield advantage correlated to higher DM in crops established with the disc opener.

There was no significant interaction between row spacing and drill opener on the yields obtained in the trial, with the 30cm row spacing yielding the least with both the tine and disc opener (see Figure 5).

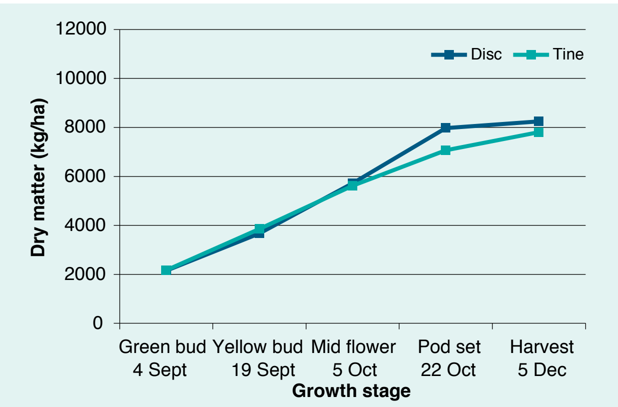

FIGURE 2 Influence of drill opener on dry matter production*
* Mean of three row spacings (4 September – 5 December 2012)

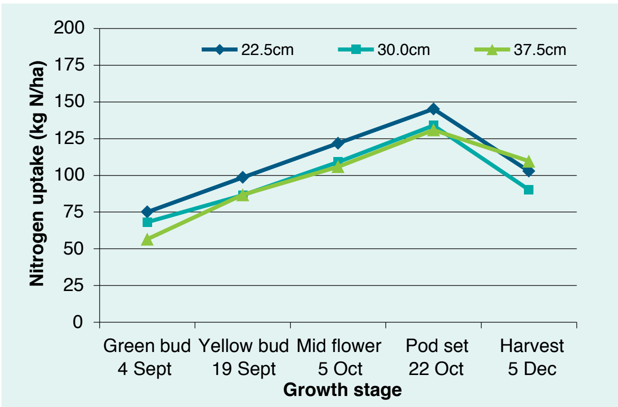

FIGURE 4 Influence of row spacing on nitrogen uptake*
* Mean of both drill openers (4 September – 5 December 2012)

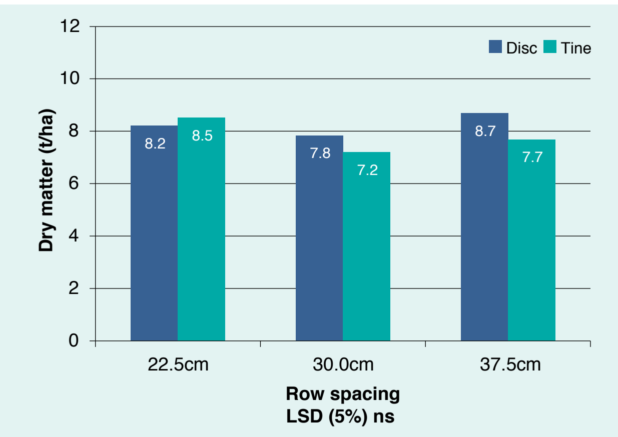

FIGURE 3 Influence of row spacing and drill opener on dry matter production at harvest

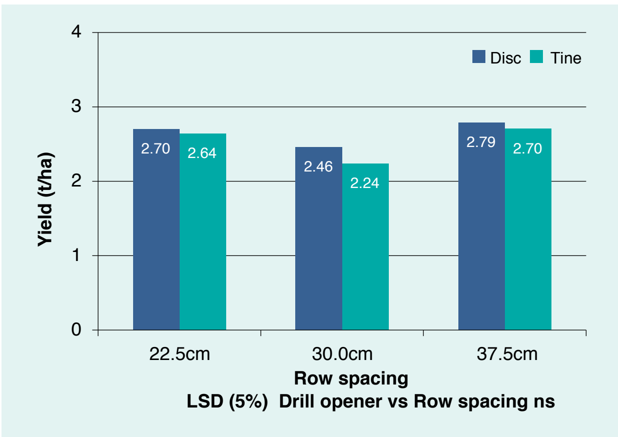

FIGURE 5 Influence of row spacing and drill opener on yield



ii) Oil content

Oil content was not significantly affected by row spacing or drill opener.

iii) Nitrogen off-take

Nitrogen in the seed accounted for about 78–81% of the nitrogen off-take, while straw nitrogen content accounted for about 19–21% of total nitrogen off-take (figures that were consistent across the different row spacings). However, actual seed nitrogen off-take (kg N/ha) at harvest was significantly higher in crops sown at the 37.5cm row spacing compared with those sown at 22.5cm, which were in turn significantly higher than the seed nitrogen off-take of the 30cm crops (see Figure 6).

The difference in seed nitrogen followed through to the total nitrogen off-take results because there were no significant differences between the straw nitrogen contents of the different row spacings.

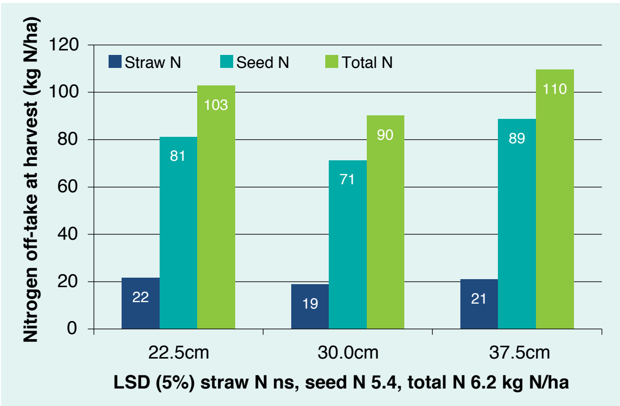

FIGURE 6 Influence of row spacing and drill opener on nitrogen off-take at harvest*

* Mean of both drill openers

Observations and comments

The widest row spacing of 37.5cm produced the highest harvest index, WUE and transpiration efficiency results (see Table 2). Results were slightly superior to the narrowest row spacing of 22.5cm. It is unclear why the 30cm row spacing was inferior to both, though it was linked to lower DM production at pod set and harvest. Unlike the wheat trials, there was less evidence of soil water being underutilised (i.e. less unproductive water) in the wider rows compared with the narrower rows.

Sponsors

This trial was carried out as part of the Riverine Plains Inc GRDC-funded project *Improved WUE in no-till cropping and stubble retention systems in spatially and temporally variable conditions in the Riverine Plains* (RP100007).

Thanks go to farmer co-operator, John Alexander and John Seidel as trial manager.

TABLE 2 Biomass at harvest, yield, harvest index (HI), water use efficiency (WUE), transpiration, evaporation/drainage and transpiration efficiency (TE)*

Row spacing (cm)	Biomass (kg/ha)	Yield (kg/ha)	HI (%)	WUE[1] (kg/mm)	Transpiration[2] (mm)	Unproductive water[3] (mm)	TE[4] (kg/mm)
22.5	8364	2670	31.9	7.6	167.3	182.7	16.0
30	7522	2350	31.2	6.7	150.4	199.6	15.6
37.5	8187	2750	33.6	7.9	163.7	186.3	16.8

[1] Based on 232mm of GSR (April – October) + 35% fallow efficiency (118mm) for January – March rainfall (total GSR + stored = 350mm) with no soil evaporation term included and assuming no drainage in periods of excessive rainfall.

[2] Transpiration through the plant based on a maximum 50kg harvest biomass/ha.mm transpired.

[3] Unproductive water (evaporation, drainage and water left unused at harvest) is the difference between transpiration through the plant and GSR (mm) + stored water at sowing.

[4] Transpiration efficiency based on kg/ha grain produced per mm of water transpired through the plant.

* Mean of both openers

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Performance of canola after two years of wheat under no-till full stubble retention (NTSR) using different drill openers and row spacing at Coreen

Nick Poole[1], Tracey Wylie[1] and John Seidel[2] in conjunction with Riverine Plains Inc

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[2] Agricultural Research Services

Key points

- Canola trials during 2012 had high plant populations, which may have created atypical crop canopy structures in relation to different row spacings.
- In four canola datasets generated from 2009 – 2012 at Coreen, New South Wales and Bungeet, Victoria the influence of row spacing on yield has been inconsistent.
- During 2012, the narrow row spacing (22.5cm) produced higher yields and a higher harvest index (HI) than wider row spacing, however this has not been the case in previous years.
- In the lowest-yielding year, 2009 (1.5t/ha average yield), the optimum row spacing was 30cm, which was significantly higher yielding than narrower (22.5cm) and wider (37.5cm) row spacings.
- In two datasets, the 30cm spacing yielded significantly lower than the narrow (22.5cm) and wide (37.5cm) row spacings.
- The disc opener produced higher yields than the tine opener in all four datasets, the advantage of the disc opener only being significant in 2012 (Bungeet) and 2009 (Coreen).
- During 2012, oil content in the Coreen trial was not significantly affected by row spacing or drill opener.

Location: Coreen, NSW

Rainfall:

Annual: 475.5mm (2012)
GSR: 196mm (Apr – Oct)
Stored moisture: Estimated 85mm (estimated at 35% fallow efficiency of 242mm)

Soil:

Type: Clay loam
pH (H_2O): 6.0 (2011)
pH ($CaCl_2$): 4.9 (2011)
Colwell P: 102mg/kg (2011)
Deep soil nitrogen: 57kg/ha (2011)

Sowing information:

Variety: Crusher (TT)
Sowing date: 16 May 2012
Fertiliser: 170kg/ha SuPerfect
Sowing equipment: Janke tine with Janke presswheel. Single disc opener.
Treatments: Establishment method x row spacing

Row spacing: 22.5cm, 30cm, 37.5cm

Paddock history:

2011 — wheat
2010 — wheat
2009 — canola

Plot size: 44m x 3m

Replicates: 4 (disc) 8 (tine)

Overall goal

Improved water use efficiency (WUE) in no-till cropping and stubble retention systems in spatially and temporally variable conditions in the Riverine Plains.

Aim

The aim of this trial was to evaluate the performance of canola established with different drill openers at a range of row spacings following two years of wheat under full stubble retention.



Method

A replicated experiment was established to test the effect of drill opener and row spacing on canola after two years of wheat as part of a four-year cropping rotation trial. The 2012 crop was the fourth successive crop superimposed on the original no-till stubble retention trial site.

- 2008 — triticale (farm crop)
- 2009 — canola
- 2010 — wheat
- 2011 — wheat
- **2012 — canola**

Crop stubble from the previous year's wheat crop trial was chopped and spread at right angles to the direction of plots.

Results

Crop establishment

Due to an error in sowing rate calculations, trial plots were established at a much higher sowing rate than farm practice of 2–4kg/ha. As a result, establishment counts were exceptionally high for canola. Despite this, the establishment still followed some of the trends seen in previous canola trials established as part of the four-year trial program.

The consistent trends include the reduction in plant population as row spacing increases.

In all of the four time replicates of canola in the rotation, the establishment at the 37.5cm row spacing has produced significantly fewer plants than the 22.5cm spacing at the two-true-leaves unfolded stage (see Figure 1). The 2012 results are the first where the tine opener has significantly increased establishment compared with the disc opener; this occurred at both the Bungeet and Coreen trial sites in 2012 (see Figure 2). During 2009, the disc opener produced significantly better establishment results than the tine and in 2011 there was no difference in crop establishment between openers.

In previous trials there has been no difference in the establishment between the 22.5cm and 30cm row spacings, however during 2012 at both Coreen and Bungeet, the 30cm row spacing produced significantly lower plant establishment than the narrowest spacing at 22.5cm.

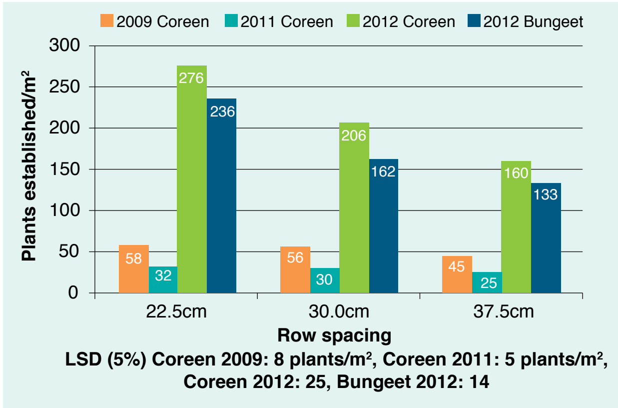

FIGURE 1 Influence of row spacing on canola plant establishment following two years of wheat at Coreen 2009, 2011, 2012 and Bungeet 2012 assessed at two-leaves-unfolded stage*

* Mean of both drill openers

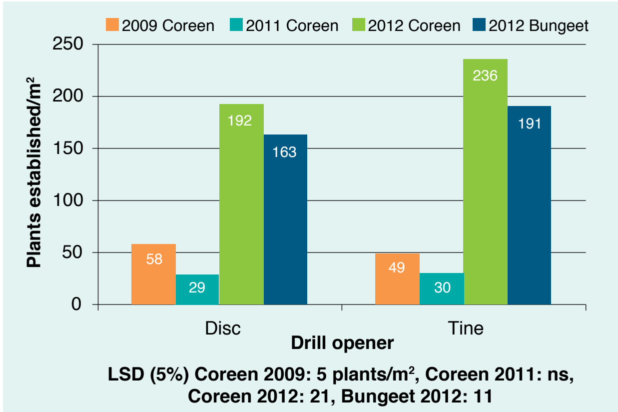

FIGURE 2 Influence of drill opener on canola plant establishment following two years of wheat at Coreen 2009, 2011, 2012 and Bungeet 2012 assessed at the two-leaves-unfolded stage*

* Mean of three row spacings

TABLE 1 Canola plant establishment at two-leaves-unfolded growth stage assessed 37 days after sowing.

Row spacing (cm)	Drill opener Plant establishment (plants/m²)		
	Disc	Tine	Mean
22.5	248	304	276
30.0	191	222	206
37.5	139	181	160
Mean	**192**	**236**	
LSD [row spacing]	25		
LSD [drill opener]	21		
LSD [disc vs tine]	36		
Interactions—drill opener x row spacing	ns		

Dry matter production

i) Row spacing

Differences in dry matter (DM) production due to crop row spacing were evident in the green bud (LSD 116kg DM/ha) and pod set (LSD 459kg DM/ha) assessments only. At these assessment timings, the 22.5cm row spacing had produced significantly more DM than both the 30cm and 37.5cm row spacings, between which there was no difference (see Figure 3).

Row spacing had less impact in this trial than in the other three trials run in the same rotation position. It is unclear how much this result is influenced by the exceptionally high sowing rates.

ii) Drill opener

There were no significant differences in DM production as a result of drill opener until the pod set assessment when the disc opener recorded significantly more DM than the tine ($p = 0.008$). At the harvest assessment, the significant DM difference was maintained ($p = 0.0167$) (see Figure 4).

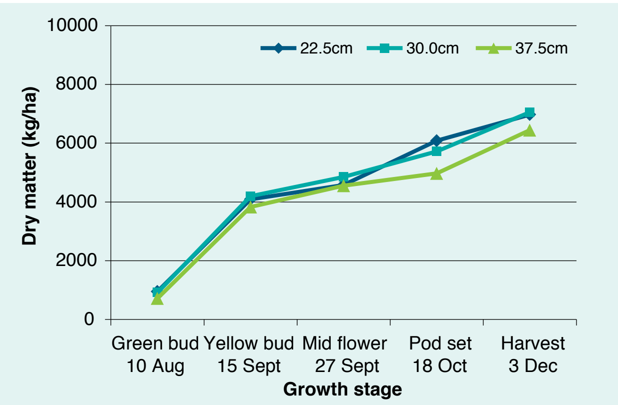

FIGURE 3 Influence of row spacing on dry matter production*

* Mean of both drill openers (4 September – 5 December 2012)

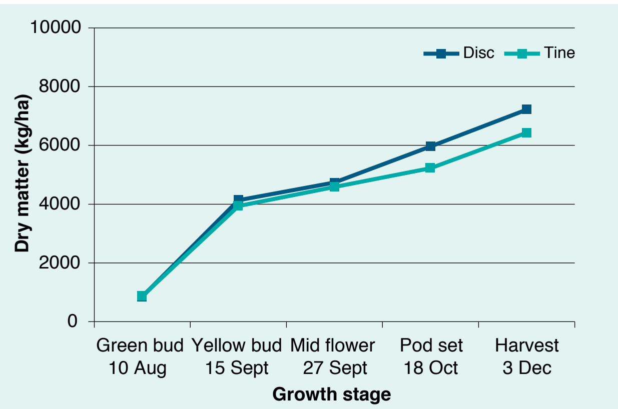

FIGURE 4 Influence of drill opener on dry matter production*

* Mean of three row spacings (10 August – 3 December 2012)

The higher DM produced with the disc opener from mid-flowering onwards was potentially linked to the relatively lower plant populations (192 plants/m^2 vs 236 plants/m^2) and better plant spacing within the row.

Across the four data sets generated from canola as part of this project, the disc opener has consistently produced more DM content than the tine opener (though this has not always been statistically significant). Initially in all data sets, there has been little difference in DM production until mid-flower/pod set where the disc opener treatment shows higher levels of DM production (see Figure 5).

There was no significant interaction between drill opener and row spacing in the DM at harvest assessment (see Figure 6).

Yield

i) Yield

Harvest data from Coreen during 2012 showed a significant yield advantage to the narrow row spacing ($p = <0.001$), with no yield difference between the 30cm and 37.5cm spacings.

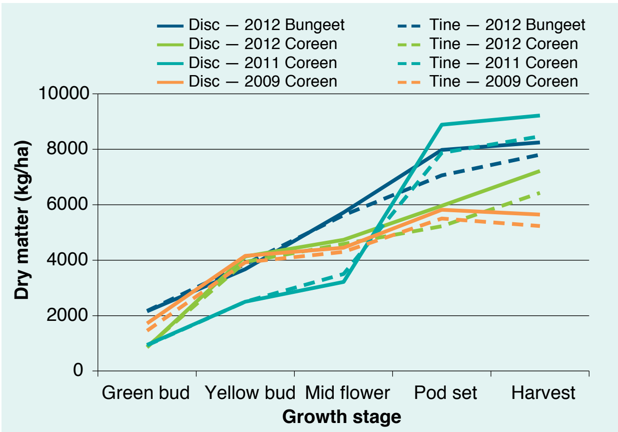

FIGURE 5 Influence of drill opener on dry matter production in canola at Coreen 2009, 2011, 2012 and Bungeet 2012*

* Mean of three row spacings

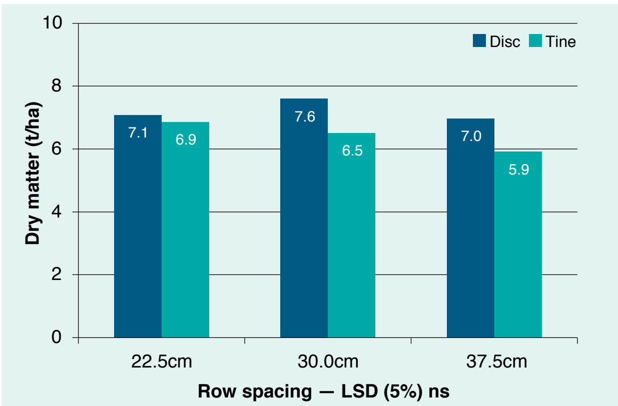

FIGURE 6 Influence of row spacing and drill opener on dry matter production at harvest*

* Mean of both drill openers

Trial yields across the four canola data sets run at Coreen in NSW and Bungeet in Victoria from 2009–2012 have ranged from 1.59–2.59 t/ha. Differences generated as a result of row spacing have been inconsistent. The canola trial at Bungeet during 2012 and at Coreen during 2011, produced similar significant results as a result of row spacing, with the 30cm row spacing being significantly lower yielding than both the 22.5cm and 37.5cm row spacings, between which there was no difference (see Figure 7). During 2009, the lowest yielding dataset (which had the lowest available levels of soil moisture) showed the reverse, with a yield advantage to the 30cm spacing over the narrower and wider row spacings.

Note: Overall, the excessively high plant populations established in two of these four datasets may have adversely influenced the effect of row spacing, though yields did not appear to be unduly compromised.

The disc opener produced higher yields than the tine opener in all four datasets, the advantage of the disc opener being significant only during 2012 (Bungeet) and 2009 (Coreen) (see Figure 8).

There was no significant interaction between row spacing and drill opener on the canola yields obtained in the 2012 trial at Coreen (see Figure 9).

ii) Oil content

Oil content was not significantly affected by row spacing or drill opener in this trial. Interestingly, the oil contents at the Coreen site were lower than those recorded at the Bungeet trial site; the Coreen site had an average oil content of 39.0% compared with 43.9% at the Bungeet site.

iii) Nitrogen off-take

Differences in the nitrogen off-take as a result of row spacing were significant in the seed component, but not in the straw component (p=0.0529) (see Figure 10).

The disc opener generated significantly greater total nitrogen off-take than the tine opener when assessed at harvest (data not presented). This difference in total nitrogen off-take stemmed from the significantly higher nitrogen off-take in the straw when the disc opener was used.

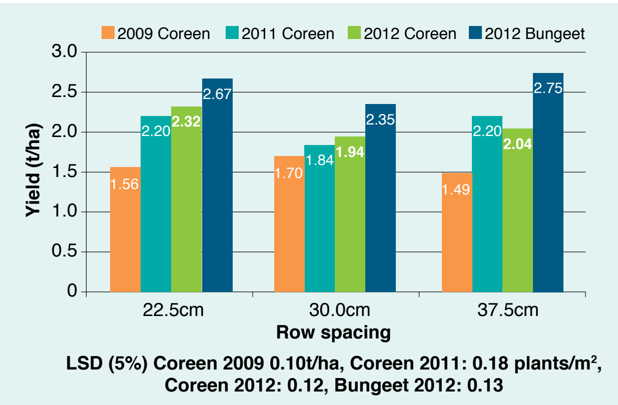

FIGURE 7 Influence of row spacing on canola yield at Coreen 2009, 2011, 2012 and Bungeet 2012*

* Mean of both drill openers

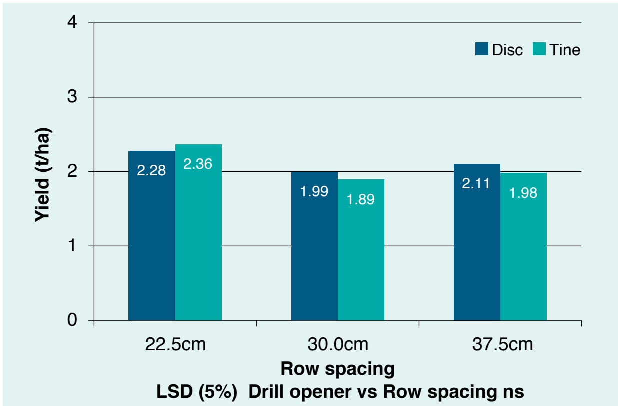

FIGURE 9 Influence of row spacing and drill opener on canola yield at Coreen 2012

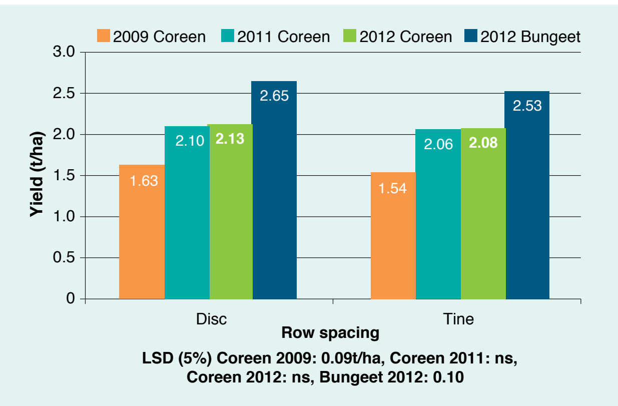

FIGURE 8 Influence of drill opener on canola yield at Coreen 2009, 2011, 2012 and Bungeet 2012*

* Mean of three row spacings

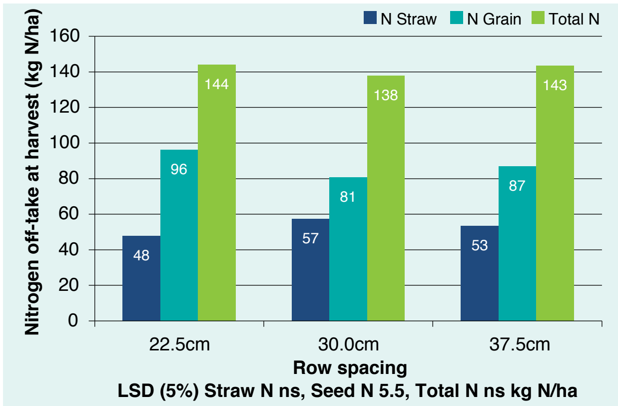

FIGURE 10 Influence of row spacing on nitrogen off-take at harvest*

* Mean of both drill openers

Observations and comments

It was estimated that the narrow row spacing produced the best overall WUE (see Table 2), though it is unclear why the harvest index at 30cm was lower than 22.5cm and 37.5cm spacings.

It is important to emphasise that the 2012 results may have been abnormally influenced by the high plant populations, driven by the excessively high sowing rate.

Sponsors

This trial was carried out as part of the Riverine Plains Inc GRDC-funded project *Improved WUE in no-till cropping and stubble retention systems in spatially and temporally variable conditions in the Riverine Plains* (RP100007).

Thanks go to farmer co-operators, the Hanrahan family and John Seidel as trial manager.

TABLE 2 Biomass at harvest, yield, harvest index (HI), water use efficiency (WUE), transpiration, evaporation/drainage and transpiration efficiency (TE)

Row spacing (cm)	Biomass (kg/ha)	Yield (kg/ha)	HI (%)	WUE[1] (kg/mm)	Transpiration[2] (mm)	Unproductive water[3] (mm)	TE[4] (kg/mm)
22.5	6972	2321	33.3	8.3	139	141	16.6
30	7051	1943	27.6	6.9	141	139	13.8
37.5	6442	2041	31.7	7.3	129	152	15.8

[1] Based on 196mm of GSR (April – October) + 35% fallow efficiency (84mm) for January — March rainfall (total GSR + stored = 281mm) with no soil evaporation term included and assuming no drainage in periods of excessive rainfall.
[2] Transpiration through the plant based on a maximum 50kg harvest biomass/ha.mm transpired.
[3] Unproductive water (evaporation, drainage and water left unused at harvest) is the difference between transpiration through the plant and GSR (mm) + stored water at sowing.
[4] Transpiration efficiency based on kg/ha grain produced per mm of water transpired through the plant.
* Mean of both openers

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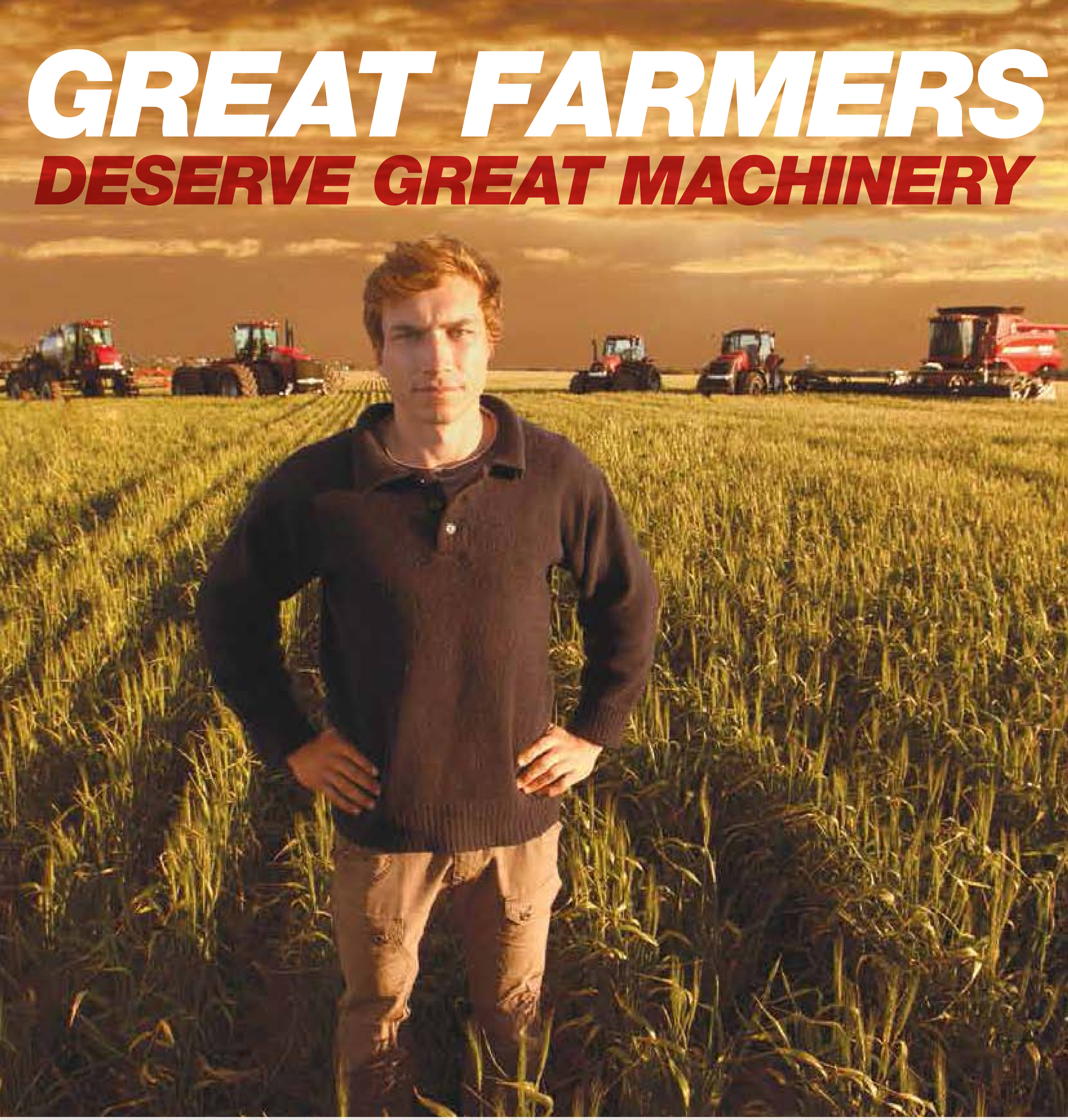

They've worked our great land since this country began. Generations of local heroes who put food on our tables and clothes on our backs. And though good times and bad times challenge them, they persist. Why? Because our proud nation depends on them. And behind every great Farmer, there are other great people. Dedicated professionals who stand behind the people on the land with what they believe are the best machines on the planet. So here's to you, the great farmers of Australia. May all the seasons ahead of you be good, and your yields even better, Because Great Farmers deserve Great Machinery,

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Break crops in cropping systems: impacts on income, nitrogen and weeds

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Key points

- Recent trials have shown crop sequences that include a brassica or legume break crop can be as profitable as, and in many instances more profitable than, continuous wheat. For instance, the most profitable cropping option at Yarrawonga during 2012 was clover hay.
- In 2013, all 2012 break crop and cereal treatments will be sown to wheat. Single year and multiple year gross margin comparisons will be made.
- The relationship between legume dry matter (DM) production and nitrogen (N) fixation found in previous studies was consistent with the results from the current trial. In most cases during 2012, higher legume DM production resulted in greater amounts of nitrogen being fixed.
- Strategic timing of operations, such as hay cutting and brown manuring, provide opportunity for improved weed control when compared with harvesting crops for grain.
- While options such as brown manuring have negative gross margins in the first year, the reduction in weed control costs and nitrogen input costs can pay off over the cropping sequence through increased profitability of subsequent wheat crops, particularly if resistant weed populations are an issue.

Background

The ability of pulse and brassica break crops to support increasing yields in subsequent wheat crops is well documented. These yield improvements arise through break crop effects on beneficial soil biology, enhanced nutrient availability, soil structural characteristics, soil moisture carryover, and/or the control of cereal diseases and insect pests.

During 2012, a trial was established at Yarrawonga South to address the renewed interest of farmers in the Riverine Plains area in growing break crops, and to help identify which break crop best fits their situation.

Key factors worthy of considering to assess crop choice and end use include herbicide-resistant weed populations, soil nitrogen concentrations and soil moisture content. The consequent economic impact depends on what influence each of these factors has on input costs (herbicides and fertiliser), income (yield and quality) and therefore gross margins.

This report details results from the first year of the trial (2012). During 2013 (year two), all treatments will be sown to wheat. Soil available nitrogen, soil moisture, yield and grain quality will be used to assess the net effect of different cropping sequences.

Aim

To determine the effect of different cropping sequences containing break crops (legumes or canola) with different end uses (grain harvested, hay cutting or brown manuring) to those with continuous cereal crops (grain harvested) in terms of income, weeds and nitrogen dynamics. The potential growth, yield and the amount of nitorgen fixed by commercial pulse crops in the Riverine Plains will be measured to determine the potential nitrogen benefits for following wheat crops.

Method

The trial was sown on the Inchbold family property at Yarrawonga South. Table 1 summarises the details of the treatments sown. Sowing was carried out on both 4 May 2012 and 1 June 2012.

Soil tests were taken at the start of 2012 to determine starting soil characteristics. Soil pH (0–10cm) ranged between 5.3–5.9 ($CaCl_2$) across the site and increased with depth. Colwell P (0–10cm) ranged from 9–22 and soil mineral nitrogen was 40–50kg N/ha in the top 60cm of soil.

TABLE 1 Trial treatments at Yarrawonga South 2012

Species	Variety	Sowing rate (kg/ha)	Sowing date
Lupins	Jenabillup	80	4/05/2012
Faba beans	Rana	160	4/05/2012
Field peas	Oura	130	1/06/2012
Chickpeas	Slasher	130	1/06/2012
Arrowleaf clover	Zulu	8	4/05/2012
Sub-clover	Antas	8	4/05/2012
Vetch	Morava	40	4/05/2012
Wheat nil fertiliser	Young	90	1/06/2012
Wheat + N fertiliser*	Young	90	1/06/2012
Canola nil fertiliser	Tawriffic	3	4/05/2012
Canola + N fertiliser*	Tawriffic	3	4/05/2012

* Topdressed as per local practice (180kg/ha urea)

During 2013, each plot will be soil tested before sowing to assess the impact of treatments on starting available soil nitrogen.

Eleven treatments were sown with MAP @ 80kg/ha in plots 20m x 1.42m, and replicated four times in a randomised block design. Pulses were inoculated with standard peat inoculant and treatments were grown according to best management practice. Both the wheat and canola + nitrogen fertiliser treatments received a total of 180kg/ha of urea during the growing season.

The field pea, sub-clover, arrowleaf clover and vetch treatments were each split in half, with one half brown manured and the other half cut for hay. Hay cut yields were calculated at 70% of peak biomass DM values. The faba bean, chickpea, wheat and canola treatments were harvested for grain at physiological maturity. The lupin treatment was sprayed out before seed set due to excessive bird damage (which made harvest unviable). Weeds such as soursob, ryegrass and marshmallow were an issue in some plots and were removed by hand.

Legume treatments were sampled at early–mid pod fill to coincide with around the time of peak biomass accumulation. Plant samples were collected to determine dry matter (DM) and estimate inputs of fixed nitrogen using a 15N-based technique.

Yield and gross margin comparisons were made between first-year break crops and wheat treatments to see if break crops could be profitable in their own right when compared with high and low nitrogen input wheat in a single year. Following the 2013 season, two-year average gross margins will be calculated to assess the impact of break crops over time in the Riverine Plains area.

Results and discussion

Flooding rainfall preceded the 2012 growing season, with more than 300mm recorded during late February–early March. This rainfall provided excellent subsoil moisture at sowing. However, the site received a total of 213mm growing season rainfall (GSR), which was below average. The wet starting conditions allowed crops to establish well with the exception of the lupins, which were severely damaged by birds.

There was a positive relationship found when legume treatments were sampled for peak biomass between legume shoot DM and the amounts of nitrogen fixed (see Table 2). In most cases, more legume DM resulted in an increased amount of nitrogen fixed.

Previous studies have shown that the percentage of nitrogen fixed by most legumes in south-eastern Australia appears to range between 60–90% of total plant nitrogen and the amount of nitrogen fixed tends to be related to biomass production (15–25kg of nitrogen fixed per tonne of shoot DM).

Provided there are adequate numbers of effective rhizobia in the soil and the concentrations of soil mineral nitrogen are not too high, the amount of nitrogen fixed will largely be regulated by legume growth rather than by the percentage of nitrogen fixed.

Well nodulated: Pulse crops in the trial nodulated well.

TABLE 2 Nitrogen fixation results for legumes sampled at peak biomass

Treatment	Mean shoot DM (t/ha)	Shoot N (kg N/ha)	% N fixed	Shoot N fixed (kg N/ha)	Shoot N fixed (kg N/t DM)	^Total N fixed (kg N/ha)
Vetch	5.1	120	79	95	19	141
Arrowleaf clover	6.1	100	81	80	13	138
Faba beans	5.3	105	82	85	16	129
Sub-clover	5.8	99	69	69	12	118
Field peas	4	93	64	58	15	86
Chickpeas	2	37	65	24	12	50
Lupins*	0.6	20	82	16	25	21
P-value	(<0.05)	<.001	<.001 NS	<.001	<.001	<.001
LSD	1.21	22	15	17	4	27

* Lupins were severely affected by bird damage and were not harvested.
^ Total nitrogen fixed (kg N/ha) estimates for the amount of nitrogen fixed from both the shoots and roots. Determined using root factors obtained from previous N fixation studies.

The vetch produced the most total plant fixed nitrogen (141kg N/ha) followed by the arrowleaf clover (138kg N/ha), faba beans (129kg N/ha) and sub-clover (118kg N/ha). These results were significantly higher than the field peas (86kg N/ha) and chickpeas 50kg N/ha) (see Table 2). Soil tests at the start of 2013 will help to identify what the net nitrogen effect the different legume treatments have on subsequent nitrogen availability for following wheat crops.

The clover and chickpeas treatments did not appear to fix nitrogen as efficiently as the other legumes with only 12–13kg fixed N/t shoot DM compared with the faba beans and field peas fixing 15–16kg fixed nitrogen per tonne of shoot DM or the 19 kg fixed nitrogen per tonne of shoot DM for the vetch (see Table 2). This may have been the result of a later than ideal timing of peak biomass sampling in the clovers (sampling closer to senescence can result in reduced nitrogen in the leaf as nitrogen is exported for seed production).

The chickpeas have less DM production than most other pulses and therefore less nitrogen was estimated to be fixed in these treatments (see Table 2). However, while chickpeas have less potential to produce as much biomass as species such as field peas and clovers, they do offer the potential to be a high value grain crop in years when grain markets favour high prices.

TABLE 3 Comparisons of grain yield, hay cut and brown manure yield, income, variable costs and gross margins near Yarrawonga during 2012

Treatment	Grain or hay yield (t/ha)	Gross income ($/ha)	Total variable costs ($/ha)	Gross margin ($/ha)
Arrowleaf clover hay cut	4.3	1324	229	1095
Sub-clover hay cut	4.0	1252	229	1023
Wheat + N	4.8	1310	323	987
Wheat - N	4.1	1066	215	851
Faba beans	3	1170	347	823
Canola + N	2.2	1206	415	791
Canola - N	1.8	965	307	658
Vetch hay cut	3.5	815	224	571
Chickpeas	1.7	799	265	534
Field pea hay cut	2.8	614	244	371
Arrowleaf clover BM	0	0	170	-170
Sub-clover BM	0	0	170	-170
Vetch BM	0	0	185	-185
Field pea BM	0	0	185	-185

Note: Grain and hay prices used in the calculations were current at the time of harvest. Variable costs were based on local practice and prices. These figures are estimated as a guide only.



The arrowleaf clover hay cut provided the highest gross margin due to the combination of high DM yields and high hay prices (see Table 3). This was followed by the sub-clover hay cut treatment and then the wheat plus fertiliser treatment. The clover hay treatments have multiple advantages for the average two-year gross margins because they potentially start with higher soil nitrogen, better weed control and higher soil moisture due to an early termination.

Above-average prices and yields were achieved for most grains; in particular wheat, faba beans and canola, which resulted in excellent gross margins for 2012. Wheat yields showed a nitrogen response with a significant difference between the plus nitrogen fertiliser treatment (4.84t/ha) and the nil treatment (4.07t/ha). There was no significant difference between canola yields +/- nitrogen.

Brown manuring provides opportunities to: maximise nitrogen carryover, deliver strategic herbicide knockdown for optimal weed control and optimise stored soil moisture. In certain situations it can provide the opportunity to rotate herbicide chemical groups to allow for a more effective reduction in problem weed populations. This is particularly relevant given the growing herbicide-resistant weed populations in many cropping areas.

Brown manuring can be timed according to the timing of weed seed set of the main target species. This timing often coincides with maximum nitrogen accumulation in the plant prior to the crop exporting nitrogen in grain development.

During 2013, gross margins in the subsequent wheat crop will be calculated on a single-year basis. Average gross margins will also be calculated for the two-year rotation. After year one, the clover treatments appear to be the most profitable. The 2013 season will help to identify the net effect of these cropping sequences in the given years.

Acknowledgments

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Willow biochar yields benefits all round

Dr Jeff Hirth
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Key points

- A high rate of biochar can improve tiller density, total dry matter and grain yield of wheat crops.
- Trials revealed no evidence of a soil nitrogen tie-up by the biochar.
- Initial soil water data suggest differences in water dynamics between surface-applied and incorporated biochar.
- Soil water differences were also apparent between 3t/ha and 54t/ha of biochar when surface-applied.

Aim

To measure the effect of willow biochar on the growth of wheat crops and the nutrient contents, organic and microbial carbon fractions, and water holding capacities of key soils in southern New South Wales and north east Victoria. Willow biochar is an ecologically-friendly form of willow timber, removed from rivers and streams, which is normally burnt.

Method

During autumn 2012, replicated field experiments were established in crop paddocks at Rutherglen, Victoria and Rand, NSW.

The experimental design consisted of five rates of willow biochar (0, 3, 6, 18 and 54t/ha) combined with two rates of fertiliser (nil and the rate used on the rest of the paddock) to give 10 treatments, which were replicated four times. The biochar application rates were calculated on the basis that 54t/ha of biochar would increase the total carbon content of the surface 30cm of soil by about 1%.

Soil moisture monitoring equipment was installed to 90cm depth at each site in the fertilised plots of the 0, 3 and 54t/ha biochar treatments of one replicate block.

Wheat emergence and tiller densities were calculated from counts of two adjacent 0.6m lengths of drill row at four random locations in each plot. Total crop dry matter (DM) was measured at flowering (October) and grain yields were measured during December using a plot harvester. Sub-samples of grain were analysed for moisture, protein and 'test weights'.

The project will continue to monitor both sites over the 2013 growing season and finish during June 2014.

Results

2012 crop growth

The treatments did not affect crop emergence counts taken during mid–late winter. However, tiller counts taken during October increased with the applied fertiliser and the highest rate of biochar at both sites (see Table 1).

At each site, crop DM yields at flowering (October) showed strong growth responses to fertiliser and a modest increase in growth at the highest rate of biochar (see Table 2).

TABLE 1 Wheat tiller density at growth stages GS31 at Rutherglen and GS38 at Rand

Biochar (t/ha)	Rutherglen			Rand		
	Fertiliser		Average	Fertiliser		Average
	Nil	Applied[1]		Nil	Applied[2]	
	(tiller/m²)			(tiller/m²)		
0	225	315	**270**	390	505	**445**
3	220	310	**265**	395	470	**430**
6	230	290	**260**	425	460	**440**
18	230	320	**275**	440	525	**480**
54	295	330	**310**	460	525	**490**
Average	**240**	**310**		**420**	**495**	
LSD 5%	**Fertiliser**	**19**			**20**	
	Biochar		**31**			**32**

[1] Fertiliser applied at Rutherglen = 125 kg MAP/ha at sowing and 150kg/ha urea during August.
[2] Fertiliser applied at Rand = 70 kg MAP/ha at sowing and 50kg/ha urea during September.



TABLE 2 Wheat dry matter yields at flowering at Rutherglen and Rand sites

Biochar (t/ha)	Rutherglen			Rand		
	Fertiliser		Average	Fertiliser		Average
	Nil	Applied[1]		Nil	Applied[2]	
	(t/ha)			(t/ha)		
0	13.6	16.3	**14.9**	3.8	9.1	**6.5**
3	11.4	14.2	**12.8**	5.0	8.0	**6.5**
6	13.6	16.7	**15.2**	4.7	8.8	**6.8**
18	13.9	16.4	**15.2**	6.8	8.4	**7.6**
54	16.9	17.0	**16.9**	7.4	10.0	**8.7**
Average	**13.9**	**16.1**		**5.5**	**8.2**	
LSD 5%	**Fertiliser**	**1.2**			**0.7**	
	Biochar		**1.9**			**1.2**

[1] Fertiliser applied at Rutherglen = 125 kg MAP/ha at sowing and 150kg/ha urea during August.
[2] Fertiliser applied at Rand = 70 kg MAP/ha at sowing and 50kg/ha urea during September.

2012 wheat grain yields

Consistent with the crop DM yields at flowering, grain yields showed the same strong response to fertiliser and a small response to the highest rate of applied biochar at both sites (see Table 3).

At the Rutherglen site, fertiliser strongly increased grain protein (see Table 4), increased grain moisture content from 10.1% to 10.6% and decreased test weight from 81.5kg/hL to 79.7kg/hL. Biochar did not affect these three measures of grain quality at the Rutherglen site.

TABLE 3 Wheat grain yields at Rutherglen and Rand sites

Biochar (t/ha)	Rutherglen			Rand		
	Fertiliser		Average	Fertiliser		Average
	Nil	Applied[1]		Nil	Applied[2]	
	(t/ha)			(t/ha)		
0	5.58	5.34	**5.46**	1.59	3.32	**2.45**
3	5.20	6.20	**5.70**	1.88	2.86	**2.37**
6	5.65	6.06	**5.86**	1.71	3.28	**2.49**
18	5.68	6.40	**5.92**	1.85	3.51	**2.68**
54	6.23	6.51	**6.37**	2.65	3.59	**3.12**
Average	**5.66**	**6.06**		**1.93**	**3.31**	
LSD 5%	**Fertiliser**	**0.34**			**0.23**	
	Biochar		**0.54**			**0.34**

[1] Fertiliser applied at Rutherglen = 125 kg MAP/ha at sowing and 150kg/ha urea during August.
[2] Fertiliser applied at Rand = 70 kg MAP/ha at sowing and 50kg/ha urea during September.

TABLE 4 Wheat grain proteins at the Rutherglen and Rand sites

Biochar (t/ha)	Rutherglen			Rand		
	Fertiliser		Average	Fertiliser		Average
	Nil	Applied[1]		Nil	Applied[2]	
	(%)			(%)		
0	9.9	11.9	**10.9**	13.4	12.8	**13.1**
3	10.1	11.9	**10.6**	11.7	12.7	**12.2**
6	10.2	11.1	**10.6**	11.3	12.3	**11.8**
18	10.3	11.4	**10.7**	12.5	12.2	**12.2**
54	10.6	11.2	**10.9**	12.2	12.4	**12.4**
Average	**10.2**	**11.4**		**12.2**	**12.5**	
LSD 5%	**Fertiliser**	**0.4**			**no effect**	
	Biochar		**no effect**			**0.5**

[1] Fertiliser applied at Rutherglen = 125 kg MAP/ha at sowing and 150kg/ha urea during August.
[2] Fertiliser applied at Rand = 70 kg MAP/ha at sowing and 50kg/ha urea during September.

At the Rand site, fertiliser did not affect grain protein, but biochar reduced grain protein across all application rates compared with the control (nil biochar). Additionally, neither fertiliser nor biochar had any effect on grain moisture (site average: 10.5 %) or grain test weight (site average: 77kg/hL).

2012 soil moisture measurements

The monthly rainfall totals (mm) received at both sites for August to December 2012 are shown in Table 5.

The water contents (mm per 100mm depth) of soil in a 100mm sphere at 10cm and 30cm depths are shown for both sites in Figures 1 to 4, from early August 2012 to early January 2013.

TABLE 5 Monthly rainfall for both sites during 2012 (mm)

Site	Aug	Sep	Oct	Nov	Dec
Rutherglen	46	13	42	19	32
Rand	46	17	23	65	8

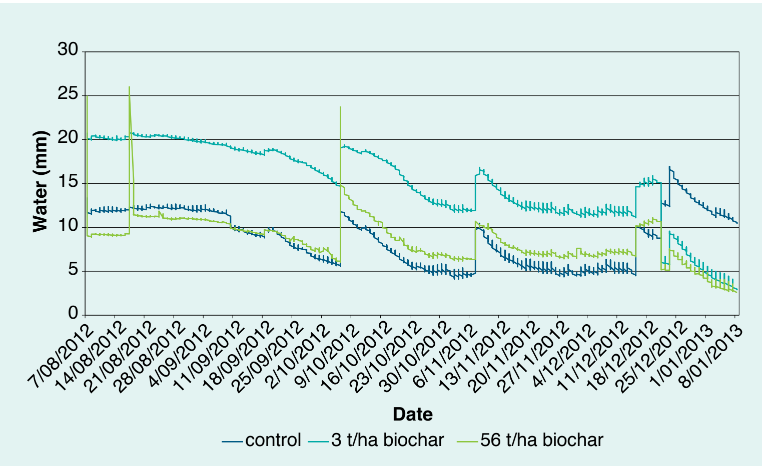

FIGURE 1 Soil water content 10cm depth — Rutherglen

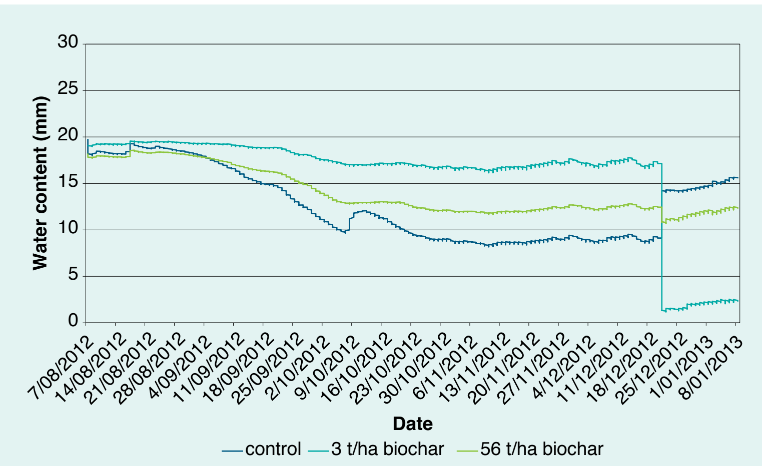

FIGURE 2 Soil water content 30cm depth — Rutherglen

The soil water traces show higher soil water contents for the 3t/ha biochar treatment (compared with 0t/ha biochar) at both 10cm and 30cm depths at both sites.

Discussion

In the year of application, plant growth responses to biochar were confined to improved tillering, increased DM at flowering and improved grain yields of wheat at both sites at the highest rate of biochar. There was no improvement in grain protein with biochar at the Rutherglen site and a decrease at the Rand site.

The nutrient content of willow biochar is, in general, dependent more on the conditions of pyrolysis than on the quality of the source stock. Generally, wood biochars are devoid of nitrogen as it is lost during heat treatment, unlike other nutrients like phosphorus, potassium and calcium, which are much more strongly retained by the biochar and very slowly released once added to soil.

However, biochar produced under lower temperatures can retain some of its labile hydrocarbons, which provide food for soil microbes and can result in more rapid microbial colonisation of biochar in the soil, with the potential of a short-term tie-up of nitrogen.

The inclusion of a fertiliser treatment in the trials meant any potential nitrogen tie-ups by the biochar could be identified. Plant growth increases measured in response to the applied nitrogen and phosphorus fertilisers at Rutherglen and Rand were not offset by decreases in plant growth where biochar was applied. That is, there were no consistent interactions across the sites between fertiliser and biochar, indicating there was no nitrogen tie-up following the application of the biochar.

As the physical structure of biochar remains quite stable during pyrolysis, and when added to soil, oxidation or weathering of the biochar only occurs at its external surfaces and so only degrades slowly in soil. Thus, it has the potential to improve the porosity, bulk density and water-holding capacity of soils over the mid-to-longer term. This project has yet to measure the porosity and bulk density of the amended soil profiles.



The soil moisture monitoring undertaken to date may provide glimpses of the impact of biochar on the water retention properties of the amended soils. It shows a trend towards higher soil water contents (compared with the control) at 10cm and 30cm depths under the 3t/ha biochar treatment. However, further monitoring is required to determine if this effect is due to the applied biochar, or to the water-holding characteristics of the soils.

The variable and generally lower soil water contents of the 54t/ha biochar treatment compared with the 3t/ha treatment may be due to the 'blanket effect' of surface-applied biochar absorbing more rainfall as it falls, decreasing the amount of water available to infiltrate into the soil profile below, as well leading to greater evaporative losses from the biochar 'blanket' immediately following rainfall events.

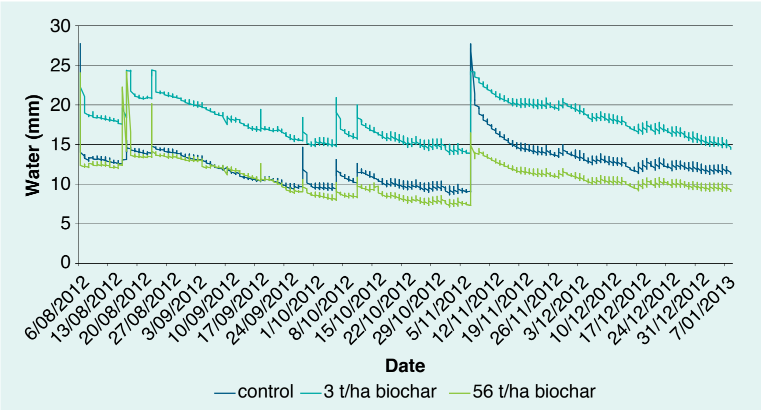

FIGURE 3 Soil water content 10cm depth — Rand

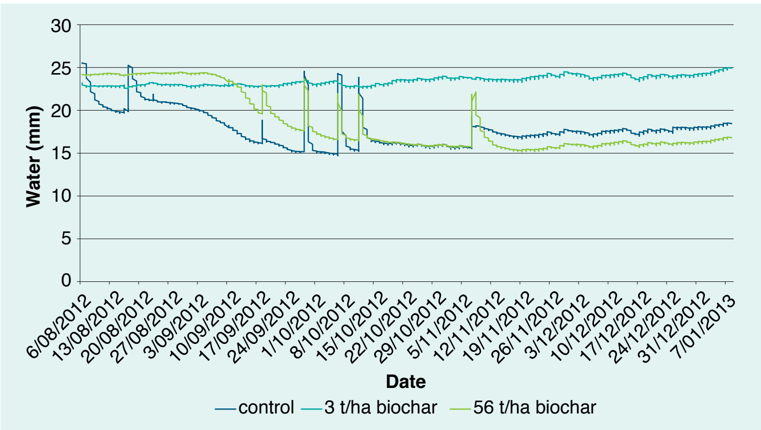

FIGURE 4 Soil water content 30cm depth — Rand

Sponsors

This project is supported by the Australian Government, Department of Agriculture, Fisheries and Forestry (DAFF) through their *Carbon Farming Initiative — Biochar Capacity Building Program* for understanding and observing the benefits of biochar in the carbon cycle. Thanks go to the farmer co-operators, the Baker Seed Co near Rutherglen and the Wolfenden family near Rand for their support, and to NECMA staff for their assistance with field work.

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Subsoil manuring shows increasing benefits with time

Renick Peries[1], Jaikirat S Gill[2] and Kithsiri Dassanayake[3]
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Key point

- Subsoil manuring produced significantly better results in the second year after manuring at a north east Victoria trial site. This is consistent with the results across other sites in the Victorian high-rainfall zone.

Location: Dookie, Victoria
Rainfall:
Annual: 620mm
GSR: 237mm
Soil:
Type: Loam over medium clay
pH (H_2O): 5.8
Sowing information:
Variety: Whistler
Sowing date: 1 May 2012. Sown on a full profile due to summer rain
Sowing rate: 85kg/ha
Fertiliser: 100kg DAP@ sowing and 200kg urea in August
Sowing equipment: Commercial air seeder
Harvest date: 7 December 2012
Row spacing: 30cm
Paddock history:
2011 — wheat
Plot size: 4m x 10m
Replicates: 4 (randomised block)

Aim

To test the effect of subsoil manuring compared with a number of other treatments used to increase the 'bucket size' of heavy clay hostile subsoils in the region.

Method

Large volumes (20t/ha) of poultry manure were placed at depth (30–40cm) and compared with a range of other treatments involving deep ripping and nutrients at two sites at Dookie, Victoria (Stewarton and Dookie college) with subsoil differences.

The manure was obtained from a local poultry farm near Dookie and contained 3.8% nitrogen, 1.8% phosphorus and 1.6% potassium.

The deep rip plus nutrients treatments provided the crop with the inorganic nutrients to match the manure.

At the Stewarton site, an additional treatment examined the effect of manure spread on the surface instead of placing it in the subsoil.

At the Dookie College site, an additional treatment investigated the placement of biochar in the subsoil.

All treatments were managed to best practice, with basal and topdressing fertiliser applied as per rest of the paddock.

The year 2012 was the second year subsoil manuring was carried out.

Results

The results outlined in Table 1 are consistent with the results obtained at other sites across high-rainfall southern Victoria where subsoil manuring appears to offer large yield advantages compared with other treatments.

The main drawback to date has been the high cost of the manuring operation: however emerging cost:benefit data suggests the cost may not be as significant an issue as previously thought given the sustained changes in soil physical properties, which deliver significantly better yields in the short–medium term (currently seven$^+$ years).

The Stewarton site data (see Table 2) suggests the effect of the manure is not only from the nutrients it contains, but the changes in the soil–clay matrix that helps the 'bucket size' increase as demonstrated in earlier trials on subsoil manuring. This is supported by measurements of plant available water (PAW) (to 1m depth in the soil profile) measured under a rain-out shelter at the Stewarton site,



TABLE 1 Results for the subsoil manuring trial site at Dookie College

Treatment	Heads/m²	Grains/head	Grain weight (mg)	Yield (t/ha)
Control	294	42.2	43.4	5.4
Deep rip only	338	40.6	43.5	5.9
Deep rip+nutrients (N, P, K)	381	44.9	43.6	7.4
20t/ha poultry manure@depth	**467**	**43.6**	**47.1**	**9.6**
Biochar (3.5t/ha)@depth	322	42.8	43.5	5.9
LSD	98.2	5.3	3.6	1.8
FProb	0.016	0.525	0.178	0.001

TABLE 2 Results for the subsoil manuring trial site at Stewarton site

Treatment	Heads/m²	Grains/head	Grain weight (mg)	Yield (t/ha)
Control	402	29.3	41.7	4.9
Deep rip only	486	28.5	41.4	5.7
Deep rip+nutrients	402	32.8	42.7	5.6
20t/ha poultry manure@depth	**582**	**38.1**	**42.5**	**9.4**
20t/ha poultry manure on surface	**525**	**29.0**	**41.6**	**6.2**
LSD	105	5.0	2.5	1.3
FProb	0.009	0.005	0.773	0.001

which showed 240mm PAW for the subsoil manuring plots, compared with 158mm in the control untreated plots. This is a 52% increase in bucket size.

A full cost:benefit analysis is being carried out and the results will be reported during 2014.

Acknowledgments

This trial is being carried out as part of a GRDC-funded project *Validation of subsoil manuring-SFS00019* and is led by La Trobe University with collaboration from DPI Victoria and Southern Farming Systems.

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Lambing percentage boosted by grazing crops

Alison Frischke
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Key points

- Cereal crops provide an opportunity to increase lamb production while maintaining, or increasing, the area of land cropped.
- Early-sown crops, grazed early and moderately (green leaf is left for plant recovery) can recover to yield similar to ungrazed crops.
- During a 2012 trial, barley grazed early recovered to yield the same as ungrazed barley. Wheat grazed twice yielded 0.4t/ha less than the ungrazed control crop. Simulated grazing of canola near bud elongation (late) reduced grain yield by 0.6t/ha compared with the ungrazed canola.

Background

It has been well demonstrated that cereal and canola crops can be grazed without yield penalty in high-rainfall areas provided some general principles are followed: crops are sown early, grazed when anchored and before particular plant growth stages (before stem elongation for cereals and bud elongation for canola) and then locked-up (animals excluded) for the remainder of the season to allow biomass recovery and grain yield.

The ability of a plant to recover biomass depends on its maturity type (short vs long season) and growth habit (winter vs spring types), biomass remaining to intercept light, adequate nutrition, stored soil moisture and in-crop rainfall for the remainder of the season. If these conditions are changed or compromised, for example, in a drier or shorter growing season, crops may run out of growing season time and resources to maintain their yield potential.

Tim and Jodie Demeo, Raywood, Victoria have been grazing cereal crops since 2007 and have been able to increase their lambing percentages by up to 10% by utilising crops as green feed for ewes and lambs while legume pastures are still establishing.

In addition to increasing lambing percentages, Tim's and Jodie's approach has enabled their farm business to expand with greater cropping intensity and lamb production.

Aim

To evaluate the feed value of wheat, barley and canola crops and determine whether grazing affects crop grain yield, quality or crop recovery at a medium-rainfall site.

Method

A replicated trial was established to evaluate the effect of grazing on three crop types: barley, wheat and canola in a medium-rainfall area.

Grazed crop trials

Three square exclusion cages made from 9m panels of steel mesh were positioned 100m apart in each paddock before grazing.

Feed value, or crop dry matter (DM), was measured for barley on 4 July 2012 at early tillering (plants had 6–8 tillers and were 10–12cm high). A mob of 500 crossbred ewes in late pregnancy grazed the 40ha barley crop continuously for 10 days from 4 July.

Wheat DM was measured on 24 July at mid-tillering. The wheat had regrown from a very light graze at the two-to-three-leaf stage to a height of 21cm. A mob of 120 lambing ewes then grazed the 20ha wheat crop for 10 days, as well as adjacent barley paddock, in a 'drift lambing' approach from 24 July. Through the process, the main mob was never in a paddock for any more than 24 hours at a time. Ewes will move away from a mob to lamb. Drift lambing involves leaving ewes with lambs born during the past 24 hours in the birthing paddock, while the rest of the mob (ewes yet to lamb and ewes that have already lambed) are moved into an adjacent paddock. By moving the general mob away, newborn lambs are given better bonding opportunities with their mothers, (no disturbance for at least the first six hours), reducing mis-mothering and improving lamb survival. After 24 hours the process happens again, where the new mothers are left in the second paddock, while the rest of the mob is moved back with the ewes that lambed 24 hours ago in the first paddock.

Canola was going to be grazed and was sampled on 4 July in preparation for grazing, but a series of unforeseen circumstances prevented this. A late start to the season, followed by further dry weather and a lack



of confidence (a predicted El Nino finish) combined with rain, which made the paddock unsuitable for grazing when the canola was ready. Grazing was simulated using a lawn mower inside the caged areas on 24 July. The crop had between 6–10 leaves and buds were visible on 5% of plants.

Tissue samples were collected at each time of grazing and analysed for nutritive value.

Grazed and ungrazed crops were harvested by taking three large 1m^2 quadrat samples at each cage site. From these samples, final DM and grain yield were measured.

Grazing intensity trial

Exclusion cages within the wheat crop, small quadrats (two rows x 50cm long), were either left uncut (ungrazed), or cut to half height at about 8cm (chip grazed) or down to the white line at 2–3cm (whole plant grazed) to represent different grazing pressures.

Cuts were used to measure feed value and tissue tested for nutritive value. At crop maturity, areas were harvested for final DM and grain yield.

Results and interpretation

The seasonal break at Raywood started during February 2012, with 75mm rainfall building subsoil moisture. However, apart from some light rains allowing crops to be sown, another substantial rain wasn't received until late May.

Grazed crop trials

The nutrition value of the barley, wheat and young canola crops were high for protein, energy and digestibility (see Table 1). Fibre content was also adequate for barley and wheat, but low for the canola, sampled on 4 July (not yet ready to graze as DM too low). Although increasing by 24 July, canola DM was still short of the minimum nutritional requirements for lactating ewes and growing lambs. This common short-fall of fibre when grazing canola crops needs to be met by supplementing with high-quality hay.

The nitrate level in canola was 500ppm, a level considered safe for grazing. Subclinical effects start to take effect over 2000ppm and toxicities occur above 4000–5000ppm. The potential nitrate levels in canola again support the recommendation of providing high-quality on an ad lib basis as another feed source — canola should contribute no more than 70% of the total diet.

The canola nutrient results demonstrate the limited window available for grazing canola. While waiting for fibre content to rise, other nutrient levels start to fall and paddock conditions can change. Weed management must not be compromised either — this is one of the reasons for including canola in the cropping rotations as a break crop. Chemical withholding periods must be considered when planning and implementing grazing.

Barley was not detrimentally affected by grazing, whereas final DM production and grain yield was lower for grazed canola and wheat during 2012 (see Table 2).

The yield penalties incurred in canola and wheat are likely to be due to being grazed later in development, followed by average winter rainfall and the finish to the season that although mild, was dry. Barley was grazed earlier in the season than the other crop types and was able to recover dry matter by flowering, helping to maintain grain yield.

Oil percentage of canola grain was not affected by grazing, and averaged 45.3%.

Grazing intensity trial

Forage value was reduced by 40% when grazing half the crop down (clip grazing) compared with grazing the crops down completely (see Table 3).

The nutritional value remained adequate as expected in both cases.

The greater the grazing intensity, the less DM the plant could recover by maturity (see Table 3). Grain yield was not affected when crops were only grazed lightly, but yield was penalised when the grazing was intensified.

TABLE 1 Nutritional value of barley, canola and wheat crops, Raywood 2012

Crop	Stage grazed	Forage DM available (kg/ha)	Crude protein (% of DM)	Neutral detergent fibre (% of DM)	Digestibility (% of DM)	Metabolisable energy (MJ/kg DM)
Barley (Gairdner)	4 July	515	27.6	41.7	74.0	12.0
Canola (Crusher)	4 July	7.6	36.5	16.5	76.5	12.5
	24 July	342	31.3	26.2	64.5	10.1
Wheat (Young)	24 July	354	33.0	32.6	79.2	13.1
Minimum nutritional requirement for lactating ewes and lambs			*>16%*	*>30%*	*>75%*	*>11*

TABLE 2 Final DM production and grain yield of grazed and ungrazed crops, Raywood 2012

Crop	Date sown	Stage grazed	Maturity DM (t/ha)			Grain yield (t/ha)		
			Ungrazed	Grazed	*Sig. diff.*	Ungrazed	Grazed	*Sig. diff.*
Barley (Gairdner)	24 April	Early tillering	9.67	9.74	*ns*	4.03	3.79	*ns*
Canola (Crusher)	27 March	6–10 leaf	9.64	7.05	*P<0.001* *LSD = 0.95* *CV% = 10.5*	3.01	2.37	*P=0.003* *LSD = 0.39* *CV% = 12.8*
Wheat (Young)	10 May	3 leaf and mid tillering	10.61	8.81	*P<0.001* *LSD = .71* *CV% = 6.7*	3.30	2.88	*P=0.009* *LSD = 0.29* *CV% = 8.6*

TABLE 3 Nutritional value of wheat grazed to different heights at mid tillering, Raywood 2012

	Forage DM available (kg/ha)	Crude protein (% of DM)	Neutral detergent fibre (% of DM)	Digestibility (% of DM)	Metabolisable energy (MJ/kg DM)
Clip grazed	214	34.7	31.2	80.8	13.4
Whole plant grazed	354	33.0	32.6	79.2	13.1
Min. req. for lactating ewes and lambs		*>16%*	*>30%*	*>75%*	*>11*

This small trial demonstrated it is best to leave some green plant material in the paddock to facilitate better plant recovery post grazing, especially if soil moisture conditions or the season outlook is looking marginal. This is how Tim and Jodie approach grazing management of their crops — animals are often only in the paddock for 24–36 hours before being moved and plants are rarely grazing more than 10cm down.

The reduced DM of grazed crops at maturity has made stubble management easier when sowing crops into these areas the following season.

In general, Tim and Jodie feel crop yields on their farm have not been penalised significantly by grazing, achieving comparable yields to their own ungrazed crops and similar crops in the district.

The benefit of using grazing crops to increase lamb production while at the same time being able to increase the cropping percentage of their business, has far outweighed any compromises incurred by any changes in grain yield, weed control (chemical withholding periods) and managing the timing of topdressing of urea.

TABLE 4 Final DM production and grain yield of wheat ungrazed and grazed to different heights at mid tillering, Raywood 2012

Grazing pressure	Maturity DM (t/ha)	Grain yield (t/ha)
Ungrazed	11.48	3.42
Clip grazed	10.06	3.24
Whole plant grazed	7.90	2.42
Sig. diff.	*P=0.002*	*P=0.062*
LSD (P<0.05)	*1.10*	*0.85*
CV%	*5*	*12.4*

Acknowledgments

This project is supported by Northern Victoria *Grain and Graze 2* (GRDC project BWD00018; funded by GRDC and Caring for Our Country). Thanks also go to the Demeo family as farmer cooperators, and Rohan Pay for technical field support.

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Weed seed control at harvest tackles ryegrass resistance

Charlotte Aves[1] and Michael Walsh[2]
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Key points

- Trials in South Australia, Victoria and New South Wales showed an average reduction in annual ryegrass emergence of 55% following the use of harvest weed seed control (HWSC) techniques.
- There was no difference in weed control provided by the Harrington Seed Destructor (HSD), narrow-window burning or chaff carts.
- The impact of the HWSC system was more evident at sites with low annual ryegrass densities.

Aim

The aims of these trials were to:

- Establish the efficiency of harvest weed seed control (HWSC) techniques across a diverse range of farming environments in southern Australia by comparing their impact on annual ryegrass populations.
- Provide an opportunity for growers in South Australia, Victoria and New South Wales to see the systems in operation on a commercial scale.

Method

A total of 14 trial sites were established across SA, Victoria and NSW (see Figure 1). A Harrington Seed Destructor (HSD), attached to a 9650 John Deere Header was transported between sites, covering a distance of approximately 6000kms in 16 days.

Fully-replicated trials comparing the HSD, narrow-windrow burning and chaff carts were compared with a conventionally-harvested control treatment. Two of these 14 trials were in the Riverine Plains region — at Dookie, Victoria and Rand, NSW.

Annual ryegrass plant densities and seed numbers above 15cm cutter bar height were recorded across each site before harvest.

Following autumn rains the sites were re-visited and ryegrass emergence counts were completed.

FIGURE 1 Ryegrass resistance trial sites

Results

Across all sites, the average annual ryegrass plant density at harvest was six plants/m^2 (see Table 1). Dookie had the highest density of annual ryegrass plants, with 15 plants/m^2 while the Arthurton, SA and Old Junee, NSW sites had one plant/m^2.

Seed number above cutter bar height indicated the seed collection potential and varied markedly between sites. The lowest was 28 seeds/m^2 and the highest was above 4000 seeds/m^2. These high seed production numbers from relatively low plant densities indicate the potential for seed bank replenishment.

Plant counts were carried out at each site on emerging annual ryegrass plants the following autumn. Where HWSC techniques were used, these plant counts showed an average reduction in emergence of 55% when compared with the conventionally-harvested control treatment.

TABLE 1 Annual ryegrass plant density at wheat harvest and seed production above harvester cutting height (15cm) at each of the 14 trial sites

Location	Annual ryegrass	
	(plants/m^2)	(seeds/m^2)
Arthurton, SA	1	28
Bute, SA	5	591
Cummins, SA	5	1039
Minnipa, SA	6	1675
Pinnaroo, SA	6	356
Dimboola, Victoria	2	138
Dookie, Victoria	**15**	**2509**
Underbool, Victoria	1	59
Coonamble, NSW	10	796
Harden, NSW	11	4017
Old Junee, NSW	1	286
Peak Hill, NSW	8	2879
Rand, NSW	**5**	**2127**



TABLE 2 Annual ryegrass plant density emerging in autumn and reductions in emergence due to HWSC treatments at each of the 14 trial sites

Location	Treatment	Annual ryegrass plant density (plants/m²)	Reduction in annual ryegrass seed population (%)
Minnipa	Control	329	
	Chaff cart	249	21
	Windrow burn	231	47
	HSD	245	26
	LSD (P=0.05)		66
Minnipa Ag centre	Control	209	
	Windrow burn	84	60
	HSD	62	70
	LSD (P=0.05)		66
Cummins	Control	425	
	Chaff cart	156	66
	Windrow burn	144	66
	HSD	160	62
	LSD (P=0.05)		29
Bute	Control	89	
	Chaff cart	43	52
	Windrow burn	46	49
	HSD	44	51
	LSD (P=0.05)		39
Arthurton	Control	12	
	Chaff cart	3	75
	Windrow burn	1	90
	HSD	2	86
	LSD (P=0.05)		12
Pinnaroo	Control	174	
	Chaff cart	93	46
	Windrow burn	55	68
	HSD	55	69
	LSD (P=0.05)		26
Underbool	Control	0.15	
	Windrow burn	0.05	67
	HSD	0.14	91
	LSD (P=0.05)		27
Dimboola	Control	14	
	Chaff cart	5	64
	Windrow burn	6	53
	HSD	7	46
	LSD (P=0.05)		29
Dookie	Control	4619	
	Windrow burn	1638	64
	HSD	1975	55
	LSD (P=0.05)		37
Rand	Control	238	
	Chaff cart	161	32
	Windrow burn	170	29
	HSD	148	38
	LSD (P=0.05)		31
Old Junee	Control	2	
	Windrow burn	1.1	55
	HSD	1.4	70
	LSD (P=0.05)		38
Harden	Control	1117	
	Windrow burn	722	35
	HSD	720	35
	LSD (P=0.05)		37
Peak Hill	Control	358	
	Windrow burn	179	50
	HSD	200	56
	LSD (P=0.05)		33
Coonamble	Control	208	
	Windrow burn	98	53
	HSD	114	45
	LSD (P=0.05)		9
Average reduction in ryegrass emergence across all sites			**56**

There was no difference between the HSD, narrow-windrow burning or chaff cart treatments. This result was similar to that achieved in Western Australia the previous season.

In general, where weed numbers were higher post treatment, the reduction in annual ryegrass emergence due to HWSC treatment was lower. For example at the Rand site there were five plants/m^2 at harvest, which produced 2127 seeds/m^2 above 15cm. The reduction in ryegrass emergence due to HWSC treatment was only 33% when compared with the conventional harvest treatment. However, where population numbers were lower at harvest, the efficacy of HWSC treatments was much greater. Taking Arthurton as an example, the annual ryegrass weed population was only one plant/m^2 at harvest and this plant population only produced 28 seeds/m^2 above 15cm. The average reduction in ryegrass from HWSC was 84% (see Table 2).

Observations and comments

Harvest weed seed control techniques provide an opportunity to capture and destroy seeds on weeds that have escaped in-season weed control. There is no difference between the techniques if they are implemented correctly and each provides an average of 55% reduction in ryegrass emergence. Therefore, growers can pick a technique that fits with their cropping system and what they are prepared to invest in terms of capital and time in follow-up operations.

These techniques need to be included as part of a comprehensive weed management system. Where seed banks are already well established, HWSC is not a silver bullet and weed numbers will take longer to reduce.

Sponsors

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Impacts of different weed management strategies on long-term annual ryegrass control

Sam Kleemann, Gurjeet Gill and Chris Preston
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Key points

- Strategic use of oaten hay is the best tool available for reducing the seedbank of annual ryegrass.
- Successful crop-topping is vital in pulse crops to prevent large increases in annual ryegrass and is becoming more important as ryegrass resistance becomes more widespread.
- Careful monitoring of ryegrass development alongside crop development during the growing season is essential to maximise crop yield and ryegrass control.
- Depletion of the ryegrass seed bank is greatest when successive years of effective weed management are implemented, combining both herbicide and mechanical means of control.

Background

Annual ryegrass is a major weed of the southern Australian wheat-belt, which naturalised after its introduction as a pasture species. If not managed effectively, ryegrass can significantly reduce crop yield potential. During the past growers could effectively control ryegrass in crops with selective grass herbicides. However, many populations of ryegrass have since developed resistance to these herbicides making post-emergent control difficult.

As a consequence, growers need to consider carefully how to best manage ryegrass populations. This consideration starts with the choice of crop each year and the associated weed control options available. A succession of years with multiple and varied control options, used in each rotation phase can be key to successful ryegrass management.

A field experiment was undertaken at Roseworthy, South Australia from 2009 to 2012 to evaluate the impact of different weed management strategies on long-term control and seed bank changes of ryegrass.

Aim

To evaluate the impact of different weed management strategies on long-term control and seed bank changes of ryegrass.

Method

Weed management strategies

Three different weed management strategies (MS1–3) were used to control ryegrass in each phase of a four-year cropping rotation (see Table 1). The cropping rotation of oaten hay–peas–wheat–barley was representative of district practice.

The experiment was set up as a randomised block design with three replicates. Plots were 15m by 20m during 2009 and 2010, and 5m by 20m during 2011 and 2012. The ryegrass population at the site was thought to be resistant to both Group A and B herbicides, and appeared to show low levels of resistance to Select® (Group A).

Ryegrass seed bank

The seed bank of ryegrass in this trial is a naturally-occurring population in the paddock and its size was estimated by taking soil cores during March of each trial year.

Before the start of the study (March 2009) 168 cores (10cm diameter) were taken across the entire experimental site to determine the initial size of the seed bank. In the following year 28 cores (10cm diameter) were taken along the two diagonals of a plot. During the last two years of the study, 10 soil cores (10cm diameter) were taken from each plot.

Soil samples collected from each plot each year were bulked together and the entire sample was used to determine the ryegrass seed bank. This was done by placing a thin layer of field soil over a layer of potting mix in plastic trays. The trays were watered and placed outside during March–July. Seedlings that emerged were recorded and removed at regular intervals. Census for ryegrass ceased during late July when no new seedlings emerged over a three-week period.



TABLE 1 Ryegrass management strategies employed for each rotation phase, Roseworthy 2009–12

Management strategy		2009	2010	2011	2012
MS1		**Oaten hay**	**Peas**	**Wheat**	**Barley**
Herbicide	IBS*:		Trifluralin	Boxer Gold®	Trifluralin
	In-crop:				
Other control:		Hay cut			
MS2		**Oaten hay**	**Peas**	**Wheat**	**Barley**
Herbicide	IBS:		Trifluralin	Sakura®	Trifluralin
	In-crop:		Select®	Boxer Gold**	
Other control:		Hay cut			
MS3		**Oaten hay**	**Peas**	**Wheat**	**Barley**
Herbicide	IBS:		Trifluralin	Boxer Gold	Trifluralin
	In-crop:		Select		
Other control:		Hay cut	Roundup crop-top	Roundup crop-top	

* IBS, Incorporated at sowing.
**Boxer Gold is not registered for post-emergent use and was undertaken for experimental purposes only.

Results and discussion

The trial site at Roseworthy, SA had a high density of ryegrass at the start of the study in 2009 (4819 seeds/m^2), but all three management strategies reduced these levels below 3100 seeds/m^2 by the start of 2012.

In the first year of the study (2009), oaten hay was extremely effective in causing a significant reduction (86%) in the seed bank of ryegrass, reducing ryegrass seeds/m^2 from the initial 4819 seeds/m^2 to only 692 seeds/m^2 after one year (see Figure 1).

Cutting hay prevents ryegrass seeds entering the seed bank provided it is carried out early and regrowth is effectively controlled with heavy grazing or non-selective herbicides (i.e. glyphosate or paraquat). Oaten hay has proven to be so effective in the management of herbicide-resistant ryegrass it has become common practice for many growers in mid-north SA.

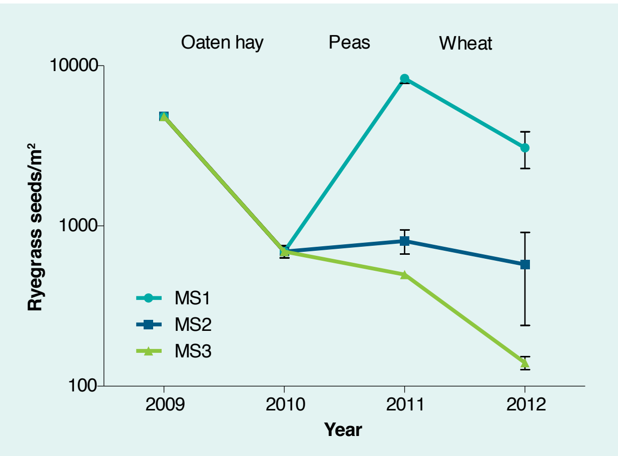

FIGURE 1 Changes in ryegrass seed bank at Roseworthy, SA under three different weed management strategies (MS1–3), 2009–12

Note: Bars represent standard error (SE) of the mean.

To provide successive years of effective ryegrass management, field peas were sown in the second year of the study (2010). During this phase, trifluralin was either applied alone (MS1), followed by the grass-selective herbicide Select (MS2), or followed by Select plus crop-topping with Roundup glyphosate (MS3).

When trifluralin was used alone it was particularly ineffective against ryegrass and seed bank levels increased dramatically from 692 seeds/m^2 to 8319 seeds/m^2. This is not surprising given many populations of ryegrass in SA are now resistant to trifluralin and field peas are considered a poor weed competitor.

Surprisingly, the ryegrass seedbank under MS2 showed little change from 2010 (692 seeds/m^2) to 2011 (806 seeds/m^2) when Select herbicide followed trifluralin. However, this population was later found to have low levels of resistance to Select, and the few survivors (10%) were capable of replenishing the seed bank.

Resistance to Select is on the increase in SA, which is a major concern given the herbicide's importance for providing effective control of ryegrass in break crops (i.e. pulses and canola).

Only when crop-topping was undertaken did the seed bank decline further (<500 seeds/m^2) and this was most likely related to reduction in ryegrass seed viability.

Crop-topping is known for its extreme sensitivity to application and is a compromise between crop damage and ryegrass control. The optimal timing for ryegrass seed set reduction will be around flowering, which can occur before optimal timing for crop safety of some pulses. Field peas tend to be better suited to crop-topping than either lentils or chickpeas, with earlier-maturing varieties generally less affected than those maturing later.

The wheat crop that followed during 2011 reduced ryegrass seed bank levels for each of the three management strategies, with pre-emergence herbicides; Boxer Gold and Sakura providing excellent residual control.

The most effective treatment was a combination of Boxer Gold implemented before sowing (IBS) followed by a late crop-top of glyphosate (MS3), which reduced the seed bank to <140 seeds/m^2.

Roundup Attack is the only glyphosate product currently registered for crop-topping wheat. The conditions for use restrict its application to grain moisture levels of 28% or less. Slightly earlier than optimal timing of crop-topping in wheat with glyphosate can result in significant penalties in grain yield and quality and growers should always adhere to label recommendations.

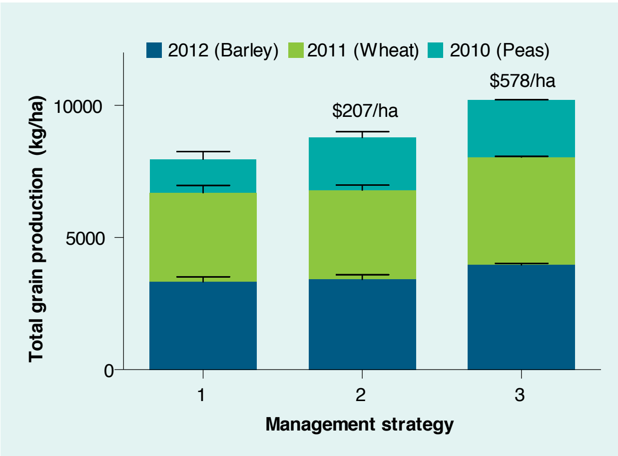

FIGURE 2 Total grain production (kg/ha) at Roseworthy under three different weed management strategies (MS1–3), 2010–12
Bars represent standard error (SE) of the mean.

Note: Values provided for management strategies 2 and 3 indicate improvement in gross return ($/ha) compared with management strategy 1 ($2029/ha). Commodity prices were sourced from *2013 Farm Gross Margin and Enterprise Planning Guide*, Rural Solutions, SA.

Earlier maturing wheat varieties, such as Axe, which was used in this study, would be far better suited to crop-topping than a later-maturing variety, such as Yitpi.

At the start of 2012 the ryegrass seed bank under effective management strategies 2 and 3 had been depleted by as much as 88% and 98% respectively of the initial seed bank (4819 seeds/m^2). Not only was the seedbank returned to more manageable levels under these two strategies, but significant improvements in total grain production and profitability resulted (see Figure 2).

Early ryegrass intervention under management strategies 2 and 3, where ryegrass competition was reduced, provided an additional $207/ha and $578/ha above management strategy 1 ($2029/ha).

Reducing the size of ryegrass seed bank can also significantly reduce the risk of herbicide resistance development, particularly when used as part of an effective integrated weed management (IWM) program.

Development of cropping phases that allow for successive years of effective weed management, using both herbicides and mechanical options, can provide long-term control of ryegrass.

Sponsors

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North east Victoria National Variety Testing Trials 2012

Trials conducted by Agrisearch and NSW DPI
Data collated by Katherine Hollaway (DEPI, Horsham) and Dale Grey (DEPI, Bendigo) from data provided by the NVT website.

During the 2012 trials, the wheat, triticale and barley trials were all sprayed with fungicide.

Long-term yield data for canola, which included the 2012 results, was unavailable at the time of printing.

TABLE 1 Long-term predicted wheat yield (main season) in north east Victoria for 2008–12

Variety	Predicted yield (t/ha)	% of EGA Gregory	Site years
Scout	3.92	111	8
Impala	3.85	109	11
Suntop	3.85	109	8
Phantom	3.82	108	8
Espada	3.75	106	14
Bullet	3.72	105	6
Waagan	3.72	105	6
Correll	3.68	104	14
Estoc	3.61	102	14
Ruby	3.61	102	12
Cobra	3.61	102	3
Wyalkatchem	3.61	102	7
Beaufort	3.58	101	6
Corack	3.58	101	8
Gazelle	3.58	101	10
Gladius	3.58	101	14
Magenta	3.58	101	11
Orion	3.58	101	11
QAL2000	3.58	101	5
Wallup	3.58	101	8
Yitpi	3.58	101	11
Young	3.58	101	12
Axe	3.54	100	14
Derrimut	3.54	100	14
Gregory	3.54	100	14
Elmore CL Plus	3.54	100	6
Emu Rock	3.54	100	8
Sabel CL Plus	3.54	100	5
Barham	3.51	99	14
Guardian	3.51	99	3
Justica CL Plus	3.51	99	8
Kord CL Plus	3.51	99	5
Lincoln	3.51	99	14
Merlin	3.51	99	11
Peake	3.51	99	12

TABLE 1 Long-term predicted wheat yield (main season) in north east Victoria for 2008–12

Variety	Predicted yield (t/ha)	% of EGA Gregory	Site years
Annuello	3.47	98	2
Bolac	3.47	98	14
Gascoigne	3.47	98	12
Gauntlet	3.47	98	6
Spitfire	3.47	98	14
Merinda	3.47	98	6
Sunguard	3.47	98	5
Livingston	3.44	97	11
Catalina	3.44	97	8
Ventura	3.44	97	12
Dart	3.41	96	8
Pugsley	3.41	96	6
Sentinel	3.41	96	13
Clearfield STL	3.37	95	8
Grenade CL Plus	3.37	95	6
Shield	3.37	95	3
Bowie	3.34	94	8
Carinya	3.30	93	2
Clearfield JNZ	3.27	92	11
Preston	3.27	92	6
Chara	3.23	91	14
Crusader	3.23	91	6
Dakota	3.23	91	6
Janz	3.23	91	7
Frame	3.20	90	12
Kennedy	3.20	90	7
Yenda	3.16	89	5
Wills	3.10	87	6
Impose CL Plus	3.10	87	3
Diamondbird	3.06	86	6
Bounty	2.82	80	3
Revenue	2.79	79	5
Forrest	2.75	78	6
Rosella	2.72	77	6

TABLE 2 Long-term predicted wheat yield (long season) in north east Victoria for 2008–12

Variety	Predicted yield (t/ha)	% of Bolac	Site years
Beaufort	5.29	109	5
Preston	5.02	104	5
Elmore CL Plus	4.97	103	1
Gregory	4.88	101	5
Gascoigne	4.88	101	3
Gazelle	4.88	101	3
Sentinel	4.88	101	5
Bolac	4.83	100	5
LRPB Lincoln	4.83	100	2
Orion	4.79	99	3
Espada	4.74	98	3
LRPB Phantom	4.74	98	1
QAL2000	4.74	98	2
Forrest	4.70	97	3
SQP Revenue	4.65	96	5
Derrimut	4.61	95	3
Bounty	4.56	94	4
Eaglehawk	4.56	94	1
Wills	4.56	94	1
Estoc	4.56	94	4
Barham	4.51	93	4
Endure	4.51	93	3
McCubbin	4.51	93	1
Yenda	4.51	93	2
Chara	4.47	92	5
Diamondbird	4.47	92	1
Gauntlet	4.47	92	1
Gruner	4.42	92	1
Sunguard	4.42	92	2
Wedgetail	4.38	91	5
Kennedy	4.38	91	3
Sunzell	4.38	91	1
Naparoo	4.33	90	2
Bowie	4.29	89	1
Kellalac	4.24	88	5
Mansfield	4.20	87	4
Frelon	3.97	82	2
Whistler	3.88	80	1
Amarok	3.74	77	2



TABLE 3 Yield and quality of wheat varieties (main season) at Dookie during 2012

Variety	Yield (t/ha)	Test weight (kg/hL)	Protein (%)	Screenings <2.2mm (%)	Seed size (g/1000 seeds)
Impala	4.01	81.8	9.6	1.4	34.8
Gazelle	3.95	79.5	9.3	0.8	38.1
Espada	3.93	80.0	10.2	1.7	45.2
Phantom	3.90	81.2	10.2	0.2	46.8
Suntop	3.89	82.6	10.2	1.8	43.9
Bolac	3.87	81.9	9.8	2.8	34.3
Gregory	3.86	82.4	10.0	0.1	42.9
Elmore CL Plus	3.85	82.7	10.1	0.1	38.7
Estoc	3.84	83.4	10.2	1.3	42.0
Correll	3.83	79.4	9.9	0.1	48.2
Merlin	3.78	82.4	11.0	0.2	45.0
Grenade CL Plus	3.71	80.9	10.0	0.1	43.6
Gascoigne	3.68	83.0	10.0	0.2	43.3
QAL2000	3.67	79.8	9.1	0.1	43.8
Corack	3.66	80.7	10.5	0.1	49.0
Magenta	3.64	81.5	10.1	0.5	46.4
Peake	3.64	81.7	9.9	0.9	39.6
Lincoln	3.63	82.2	9.9	0.6	42.9
Justica CL Plus	3.62	79.9	10.0	0.2	41.0
Clearfield Stl	3.60	82.6	10.6	0.1	42.7
Wallup	3.60	81.4	10.7	0.7	41.3
Gauntlet	3.58	83.2	10.2	0.1	44.1
Orion	3.57	75.0	9.0	0.6	45.1
Scout	3.55	82.1	10.0	1.3	44.0
Spitfire	3.55	82.0	10.7	0.4	45.4
Chara	3.54	83.1	10.7	0.3	40.7
Cobra	3.54	78.9	11.4	0.2	41.3
Barham	3.52	77.8	9.6	0.1	40.1
Clearfield Jnz	3.52	82.1	10.7	1.5	41.8
Frame	3.50	82.5	10.7	1.8	48.3
Emu Rock	3.47	80.5	9.9	0.1	45.4
Axe	3.44	81.1	11.2	0.1	46.3
Dart	3.44	77.9	10.7	0.5	42.1
Derrimut	3.43	82.8	10.0	1.8	36.8
Young	3.38	82.5	10.5	0.4	37.8
Livingston	3.37	82.1	10.8	0.9	42.3
Ventura	3.35	80.8	11.6	0.1	42.2
Ruby	3.33	82.5	10.9	0.4	40.3
Gladius	3.32	81.3	10.4	0.1	45.6
Sentinel	3.28	79.9	11.4	1.2	44.9

Sown	17 May 2012		
Harvested	11 December 2012	**pH($CaCl_2$)**	4.6
Site mean (t/ha)	3.66	**GSR (Apr-Oct)**	223mm
CV (%)	3.9		
F prob	<0.001		
LSD (t/ha)	0.25		

This trial was sprayed with fungicide during August, September and October.

TABLE 4 Yield and quality of wheat varieties (main season) at Wunghnu during 2012

Variety	Yield (t/ha)	Test weight (kg/hL)	Protein (%)	Screenings <2.2mm (%)	Seed size (g/1000 seeds)
Estoc	3.71	83.6	9.8	0.6	44.9
Espada	3.69	80.4	9.1	1.0	45.5
Scout	3.65	83.0	9.8	1.1	43.5
Suntop	3.64	83.4	9.5	1.4	46.2
QAL2000	3.61	80.8	8.8	0.2	47.1
Barham	3.60	79.8	9.0	0.1	43.1
Bolac	3.60	80.2	9.3	2.8	34.3
Correll	3.60	80.1	8.8	1.6	48.3
Derrimut	3.57	82.3	9.7	1.5	38.4
Wallup	3.57	82.8	9.6	0.5	42.6
Clearfield Stl	3.56	82.9	10.1	1.1	43.0
Gascoigne	3.56	81.8	9.5	1.5	45.2
Phantom	3.54	81.5	9.2	1.1	47.2
Impala	3.53	83.0	8.5	1.0	37.6
Young	3.53	83.8	9.5	0.3	39.1
Orion	3.46	76.5	9.1	1.4	47.5
Grenade CL Plus	3.43	81.6	9.5	1.1	45.0
Dart	3.41	80.5	10.2	1.3	40.7
Gregory	3.40	82.8	9.4	1.5	43.5
Elmore CL Plus	3.40	83.2	8.9	1.5	39.5
Chara	3.36	81.7	10.5	1.3	39.9
Gauntlet	3.27	83.7	9.4	1.2	48.0
Cobra	3.26	79.2	9.9	1.6	41.7
Livingston	3.25	81.7	10.1	0.8	41.4
Merlin	3.25	84.1	10.7	0.8	47.9
Emu Rock	3.24	81.1	10.1	0.7	53.0
Gladius	3.22	80.9	10.2	0.9	45.4
Lincoln	3.17	81.7	9.0	1.4	43.5
Corack	3.15	80.7	10.4	1.6	47.2
Gazelle	3.14	78.4	8.2	1.2	37.2
Axe	3.13	81.4	9.1	0.2	46.8
Clearfield Jnz	3.13	82.5	8.8	1.0	43.1
Magenta	3.11	82.8	9.3	1.7	47.9
Frame	3.10	80.8	10.4	1.0	44.1
Spitfire	3.08	83.7	10.3	0.9	46.7
Justica CL Plus	3.04	79.8	9.4	1.1	39.2
Sown	18 May 2012	**pH($CaCl_2$)**	4.5		
Harvested	11 December 2012	**GSR (Apr-Oct)**	243mm		
Site mean (t/ha)	3.43				
CV (%)	5.9				
F prob	<0.001				
LSD (t/ha)	0.35				

This trial was sprayed with fungicide during August, September and October.

TABLE 5 Yield and quality of wheat varieties (main season) at Yarrawonga during 2012

Variety	Yield (t/ha)	Test weight (kg/hL)	Protein (%)	Screenings <2.2mm (%)	Seed size (g/1000 seeds)	Height (cm)	Flowering day
Bolac	4.55	81.8	9.6	1.3	36.8	99	276
QAL2000	4.41	81.6	9.3	0.4	48.5	96	273
Barham	4.39	79.1	9.3	3.3	43.6	98	270
Cobra	4.38	81.2	10.2	0.3	44.4	84	267
EGA Gregory	4.29	83.5	9.6	2.3	46.5	113	275
Suntop	4.29	82.6	10.1	1.9	45.8	104	271
Young	4.29	83.9	10.3	0.2	38.9	88	266
Chara	4.24	82.3	10.4	1.2	41.9	95	273
Impala	4.22	83.9	9.5	1.1	39.7	103	269
Phantom	4.20	81.8	9.6	0.1	50.5	90	272
Correll	4.19	81.0	9.4	0.3	50.3	94	269
Gauntlet	4.17	83.2	10.3	2.9	47.5	94	272
Scout	4.16	84.0	10.1	2.4	48.2	87	268
Derrimut	4.14	83.6	9.9	2.2	40.6	81	272
Elmore CL Plus	4.13	83.9	9.4	2.4	41.3	89	269
Merlin	4.09	83.2	10.9	0.2	50.4	86	264
Wallup	4.08	81.8	10.7	0.2	43.1	88	266
Dart	4.06	82.6	10.8	0.2	45.3	92	261
Espada	4.06	81.5	10.2	1.4	47.2	93	271
Clearfield Stl	3.99	82.9	9.7	1.6	46.0	98	270
Gascoigne	3.99	83.5	10.8	0.1	49.3	103	268
Livingston	3.99	81.7	10.9	0.2	43.5	96	266
Estoc	3.92	83.5	11.1	1.6	46.0	84	271
Grenade CL Plus	3.91	80.9	10.5	0.2	46.8	94	267
Gazelle	3.89	78.8	9.0	0.2	40.1	91	282
Sentinel	3.89	82.7	10.5	0.5	46.5	94	272
Magenta	3.88	83.7	10.6	0.1	50.9	91	273
Spitfire	3.88	82.9	11.4	0.1	50.3	92	267
Lincoln	3.78	82.8	9.9	0.4	47.2	94	269
Orion	3.78	76.4	8.9	0.4	47.9	104	274
Clearfield Jnz	3.69	82.7	10.3	1.7	43.8	93	267
Gladius	3.68	81.7	11.2	0.1	50.4	93	269
Emu Rock	3.66	82.2	10.7	3.1	54.8	82	263
Corack	3.64	82.0	10.3	0.1	51.3	86	266
Axe	3.55	82.3	11.3	0.1	49.8	89	262
Justica CL Plus	3.43	81.3	10.3	0.8	42.5	83	272

Sown	16 May 2012	**pH($CaCl_2$)**	6.0
Harvested	9 December 2012	**GSR (Apr-Oct)**	206mm
Site mean (t/ha)	4.04		
CV (%)	4.7		
F prob	<0.001		
LSD (t/ha)	0.34		

This trial was sprayed with fungicide during August, September and October.

TABLE 6 Yield and quality of wheat varieties (long season) at Rutherglen during 2012

Variety	Yield (t/ha)	Test weight (kg/hL)	Protein (%)	Screenings <2.2mm (%)	Seed size (g/1000 seeds)	Height (cm)	Flowering day
Estoc	5.51	81.2	11.2	1.6	42.6	97	272
Orion	5.30	72.7	9.7	1.7	44.7	109	286
Elmore CL Plus	5.16	81.6	10.6	1.9	38.6	96	271
Preston	5.15	75.5	10.4	2.0	42.9	89	271
Sentinel	5.08	79.3	10.8	1.1	44.1	97	279
Gregory	5.06	82.1	10.1	1.8	42.5	107	280
Beaufort	5.04	75.4	10.5	3.7	38.2	90	286
Bolac	5.00	77.1	10.8	4.6	33.9	103	284
Revenue	4.96	72.6	9.7	3.7	37.7	85	294
Chara	4.95	81.6	10.9	1.1	41.3	96	275
Gascoigne	4.86	82.3	11.1	1.8	45.4	104	270
Wedgetail	4.84	76.2	10.4	1.0	39.5	95	286
QAL2000	4.79	79.0	9.8	1.6	44.0	99	280
Gazelle	4.77	10.0	-	-	10.0	100	287
Gauntlet	4.75	82.5	11.1	1.2	44.2	94	276
Kellalac	4.07	78.2	10.8	1.5	35.5	95	288
Mansfield	3.82	74.5	11.2	2.5	32.8	78	302
Sown	15 May 2012		**pH($CaCl_2$)**	4.6			
Harvested	8 December 2012		**GSR (Apr-Oct)**	256mm			
Site mean (t/ha)	4.88						
CV (%)	3.8						
F prob	<0.001						
LSD (t/ha)	0.32						

This trial was sprayed with fungicide during August, September and October.



TABLE 7 Long-term predicted triticale yields in north east Victoria for 2005–12

Variety	Predicted yield (t/ha)	Site years
Fusion	3.46	6
Hawkeye	3.39	14
Berkshire	3.36	12
Canobolas	3.35	12
Chopper	3.34	10
Bogong	3.33	12
Jaywick	3.31	14
Tobruk	3.29	10
Rufus	3.15	10
Goanna	3.10	4
Tickit	3.07	5
Tahara	3.04	16
Yowie	3.03	6
Abacus	2.85	4
Tuckerbox	2.84	8

TABLE 8 Yield of triticale varieties at Rutherglen during 2012

Variety	Yield (t/ha)	Test weight (kg/hL)	Protein (%)	Screenings <2.2mm (%)	Height (cm)	Flowering day
Bogong	5.70	72.1	9.4	2.7	126	271
Fusion	5.54	71.8	9.4	2.5	116	266
Berkshire	5.41	75.2	10.0	3.7	119	269
Hawkeye	5.29	73.3	9.8	1.6	111	268
Canobolas	5.21	74.4	9.5	3.8	121	270
Chopper	5.06	69.1	9.9	2.4	88	265
Jaywick	4.97	71.4	9.4	1.7	111	267
Tahara	4.86	70.5	10.5	1.8	115	267
Goanna	4.82	75.8	9.9	1.0	120	269
Yowie	4.79	71.5	10.0	1.2	119	271
Rufus	4.76	71.3	10.1	2.4	123	266
Tuckerbox	4.08	69.5	9.7	4.8	121	272
Bogong	5.70	72.1	9.4	2.7	126	271
Sown	15 May 2012	**pH($CaCl_2$)**	4.6			
Harvested	8 December 2012	**GSR (Apr-Oct)**	256mm			
Site mean (t/ha)	5.09					
CV (%)	3.3					
F prob	<0.001					
LSD (t/ha)	0.27					

This trial was sprayed with fungicide during August, September and October.

TABLE 9 Yield of triticale varieties at Yarrawonga during 2012

Variety	Yield (t/ha)	Test weight (kg/hL)	Protein (%)	Screenings <2.2mm (%)
Berkshire	4.03	78.1	9.3	3.2
Canobolas	3.88	76.8	9.1	4.6
Hawkeye	3.88	74.9	8.7	2.3
Jaywick	3.80	73.0	9.1	2.3
Fusion	3.68	72.3	9.1	5.0
Goanna	3.63	76.4	9.5	2.6
Yowie	3.63	73.4	9.6	2.2
Chopper	3.48	69.7	9.2	4.0
Rufus	3.48	71.9	9.6	2.0
Tahara	3.47	71.4	9.4	2.4
Bogong	3.39	75.7	9.2	3.2
Tuckerbox	3.13	72.3	9.1	3.5
Sown	16 May 12	**pH($CaCl_2$)**	6.0	
Harvested	9 December 2012	**GSR (Apr-Oct)**	206mm	
Site mean (t/ha)	2.06			
CV (%)	2.4			
F prob	<0.001			
LSD (t/ha)	0.08			

This trial was sprayed with fungicide during August, September and October.



TABLE 10 Long-term predicted barley yield in north east Victoria for 2008–12

Variety	Predicted yield (t/ha)	Site years
Malting barley		
Commander	3.62	4
Fairview	3.56	4
Buloke	3.42	4
Vlamingh	3.44	2
Bass	3.40	3
Gairdner	3.28	4
Flagship	2.95	4
Baudin	3.11	4
Schooner	2.83	4
Navigator	3.14	3
Feed barley		
Hindmarsh	3.63	4
Oxford	3.86	4
Fleet	3.63	3
Fathom	3.55	3
Capstan	3.57	3
Keel	3.35	2
Shepherd	3.33	2
Barley under malt evaluation		
Henley	3.67	4
Skipper	3.50	3
Wimmera	3.58	4
Westminster	3.56	4
Macquarie	3.36	4
Scope	3.35	4
Grange	3.74	2
Flinders	3.56	3

TABLE 11 Yield and quality of barley varieties at Wunghnu during 2012

Variety	Yield (t/ha)	Test weight (kg/hL)	Protein (%)	Screenings (<2.2mm)	Plumpness (>2.5mm)	Seed size (g/1000)
Malting barley						
Commander	3.46	62.6	7.0	1.6	96.0	47.3
Gairdner	3.28	64.7	8.8	1.2	92.9	51.3
Fairview	3.21	64.2	7.9	1.8	94.0	46.2
Buloke	3.19	64.4	8.1	1.3	96.4	54.9
Bass	3.08	64.2	8.5	0.7	98.7	49.4
Baudin	3.00	65.6	8.3	0.4	98.8	48.1
Schooner	2.94	64.9	8.6	1.6	94.6	47.1
Flagship	2.33	64.6	8.8	1.3	93.4	50.8
Feed barley						
Hindmarsh	3.75	68.3	7.9	0.7	97.1	46.3
Fathom	3.59	64.3	8.0	0.7	97.6	55.9
Oxford	3.57	63.5	7.3	2.6	85.1	43.5
Scope	3.20	65.7	8.6	0.8	97.7	53.2
Barley under malt evaluation						
SY Rattler	4.41	66.1	7.3	1.3	91.0	41.8
Wimmera	3.69	63.6	8.6	0.8	95.4	45.4
Westminster	3.59	66.8	8.3	1.1	96.9	50.5
Henley	3.43	60.0	7.5	1.4	96.9	49.6
Flinders	3.38	66.2	8.3	0.6	98.1	45.9
Macquarie	3.32	66.0	8.0	2.5	85.9	49.0
Sown	18 May 2012	**pH(CaCl$_2$)**	4.5			
Harvested	11 December 2012	**GSR (Apr-Oct)**	243mm			
Site mean (t/ha)	3.54					
CV (%)	8.5					
F prob	<0.001					
LSD (t/ha)	0.49					

This trial was sprayed with fungicide during August, September and October.

TABLE 12 Long-term predicted oat yield in north east Victoria during 2005–12

Variety	Predicted yield (t/ha)	Site years
Bannister	2.69	6
Quoll	2.66	10
Potoroo	2.45	8
Possum	2.36	13
Wombat	2.36	9
Dunnart	2.32	12
Mitika	2.31	13
Yallara	2.19	13
Kojonup	2.19	6
Euro	2.18	12
Mortlock	1.84	6
Numbat	1.35	5

TABLE 13 Yield of oat varieties at Yarrawonga during 2012

Variety	Yield (t/ha)	Test weight (kg/hL)	Protein (%)	Screenings <2.2mm (%)	Seed size (g/1000 seeds)
Bannister	4.48	53.0	10.1	8.4	38.9
Quoll	4.40	52.2	9.9	10.2	38.2
Possum	4.10	54.2	11.6	9.6	38.2
Dunnart	4.01	53.1	9.8	4.0	38.4
Euro	4.00	56.0	10.7	5.7	39.2
Wombat	3.92	53.8	11.2	7.2	39.2
Mitika	3.57	53.2	11.8	2.9	42.2
Yallara	3.53	57.0	11.2	4.7	40.0
Sown	16 May 2012	**pH($CaCl_2$)**	6.0		
Harvested	9 Dec 2012	**GSR (Apr-Oct)**	206mm		
Site Mean (t/ha)	3.92				
CV (%)	3.8				
F prob	<0.001				
LSD (t/ha)	0.22				

TABLE 14 Yield of oat varieties at Dookie during 2012

Variety	Yield (t/ha)	Test weight (kg/hL)	Protein (%)	Screenings <2.2mm (%)	Seed size (g/1000 seeds)
Bannister	2.91	55.4	8.0	6.9	42.0
Dunnart	2.38	54.2	8.4	10.4	40.6
Euro	2.88	56.9	9.4	6.5	43.3
Mitika	2.15	53.4	10.5	5.5	39.1
Possum	2.64	53.1	9.9	9.2	38.2
Quoll	2.86	51.4	9.5	7.9	39.0
Wombat	2.80	54.3	9.6	10.0	38.3
Yallara	2.61	55.3	9.2	7.7	36.4
Sown	17 May 012	**pH($CaCl_2$)**	4.6		
Harvested	11 December 2012	**GSR (Apr-Oct)**	223mm		
Site mean (t/ha)	2.56				
CV (%)	5.1				
F prob	<0.001				
LSD (t/ha)	0.2				

TABLE 15 Yield of conventional canola varieties (mid season) at Wunghnu during 2012

Variety	Yield (t/ha)	Oil (%)	Protein (%)
AV Garnet	2.69	45.5	16.0
Hyola 50	2.68	45.2	17.4
AV Zircon	2.54	47.6	15.4
CB Agamax	2.50	43.6	16.7
CB Tango C	2.47	45.8	17.1
Victory V3003	2.44	45.2	16.7
Sown	4 May 2012	**pH($CaCl_2$)**	4.9
Harvested	16 November 2012	**GSR (Apr-Oct)**	243
Site mean (t/ha)	2.52		
CV (%)	5.0		
F prob	<0.001		
LSD (t/ha)	0.2		



TABLE 16 Yield of Roundup Ready (RR) canola varieties at Yarrawonga during 2012

Variety	Yield (t/ha)	Oil (%)	Protein (%)	Height (cm)	Flowering day
Pioneer 43Y23 (RR)	2.99	42.2	19.3	152	228
Nuseed GT-50	2.96	43.6	18.8	159	235
Nuseed GT-41	2.93	43.1	19.9	137	227
Hyola 404RR	2.82	45.8	18.8	148	228
Pioneer 45Y22 (RR)	2.79	41.4	20.4	146	236
CB Status RR	2.76	41.5	19.7	152	229
Monola 513GT	2.75	46.8	19.0	145	233
GT Cobra	2.69	42.9	20.5	148	235
Hyola 505RR	2.65	45.0	20.7	146	227
Victory V5002RR	2.63	42.3	21.0	151	238
IH50 RR	2.59	42.2	19.4	144	235
CB Frontier RR	2.58	39.9	20.4	149	236
CB Eclipse RR	2.54	39.3	20.5	147	227
GT Viper	2.52	42.6	19.4	140	227
Sown	7 May 2012	**pH($CaCl_2$)**	5.0		
Harvested	28 November 2012	**GSR (Apr-Oct)**	206		
Site mean (t/ha)	2.69				
CV (%)	5.1				
F prob	<0.001				
LSD (t/ha)	0.24				

TABLE 17 Yield of Roundup Ready (RR) canola varieties at Wunghnu during 2012

Variety	Yield (t/ha)	Oil (%)	Protein (%)
Pioneer 43Y23 (RR)	3.07	43.8	17.7
Pioneer 45Y22 (RR)	2.96	44.5	17.4
Nuseed GT-50	2.89	46.2	16.1
IH50 RR	2.86	43.1	17.7
Hyola 505RR	2.73	47.1	17.5
Monola 513GT	2.68	48.3	17.1
Nuseed GT-41	2.65	45.3	18.4
Hyola 404RR	2.64	46.8	17.1
CB Frontier RR	2.60	43.8	17.4
CB Eclipse RR	2.52	42.0	17.8
GT Cobra	2.50	45.2	18.2
CB Status RR	2.38	44.1	16.5
GT Viper	2.33	43.7	17.8
Sown	4 May 2012	**pH($CaCl_2$)**	4.9
Harvested	16 November 2012	**GSR (Apr-Oct)**	243
Site mean (t/ha)	2.68		
CV (%)	4.7		
F prob	<0.001		
LSD (t/ha)	0.21		

TABLE 18 Yield and quality of imidazolinone (imi) tolerant canola varieties (mid season) at Yarrawonga during 2012

Variety	Yield (t/ha)	Oil (%)	Protein (%)	Height (cm)	Flowering day
Pioneer 44Y84 (CL)	3.19	42.3	20.3	152	229
Pioneer 45Y86 (CL)	3.07	41.2	22.0	147	235
Archer	3.00	40.6	21.5	152	237
Carbine	3.00	41.3	20.7	150	226
Pioneer 45Y82 (CL)	2.96	41	21.0	144	228
Hyola 474CL	2.81	41.9	21.8	137	235
Hyola 575CL	2.65	40.4	22.6	153	235
Sown	7 May 2012	**pH($CaCl_2$)**	5.0		
Harvested	28 November 2012	**GSR (Apr-Oct)**	206		
Site mean (t/ha)	2.92				
CV (%)	4.8				
F prob	<0.001				
LSD (t/ha)	0.23				



TABLE 19 Yield and quality of imidazolinone (imi) tolerant canola varieties (mid season) at Wunghnu during 2012.

Variety	Yield (t/ha)	Oil (%)	Protein (%)
Archer	2.87	43.6	17.0
Pioneer 45Y86 (CL)	2.73	45.1	17.2
Pioneer 45Y82 (CL)	2.68	43.3	17.9
Pioneer 44Y84 (CL)	2.62	45.2	17.3
Hyola 474CL	2.59	44.4	19.1
Carbine	2.50	44.7	17.8
Hyola 575CL	2.48	44.4	18.5
Sown	4 May 2012	**pH($CaCl_2$)**	4.9
Harvested	16 November 2012	**GSR (Apr-Oct)**	243
Site mean (t/ha)	2.66		
CV (%)	4.8		
F prob	<0.001		
LSD (t/ha)	0.2		

TABLE 20 Yield and quality of triazine tolerant (TT) canola varieties (mid season) at Yarrawonga during 2012

Variety	Yield (t/ha)	Oil (%)	Protein (%)	Height (cm)	Flowering day
CB Junee HT	2.95	41	20.2	148	227
ATR Gem	2.94	44	19.8	141	235
Hyola 559TT	2.93	43	21.5	142	234
CB Nitro HT	2.89	42	22.8	135	223
Hyola 656TT	2.89	41	23.2	136	236
Crusher TT	2.84	40	21.0	142	235
CB Atomic HT	2.81	40	22.6	147	230
CB Henty HT	2.81	41	21.4	147	230
ATR Snapper	2.77	45	19.9	133	227
CB Sturt TT	2.76	41	21.7	135	224
Hyola 555TT	2.75	41	21.8	136	229
ATR Stingray	2.71	43	21.2	114	223
CB Jardee HT	2.70	40	21.3	134	235
Monola 413TT	2.69	43	22.1	140	230
Jackpot TT	2.67	44	21.0	134	236
Monola 506TT	2.63	42	21.5	147	229
ATR Cobbler	2.57	41	22.1	137	228
Bonanza TT	2.54	42	21.9	123	226
Monola 605TT	2.50	41	21.3	147	233
Thumper TT	2.49	43	21.6	120	231
Sown	7 May 2012	**pH($CaCl_2$)**	5.0		
Harvested	28 November 2012	**GSR (Apr-Oct)**	206		
Site mean (t/ha)	2.75				
CV (%)	5.0				
F prob	<0.001				
LSD (t/ha)	0.24				

TABLE 21 Yield and quality of triazine tolerant (TT) canola varieties (mid season) at Wunghnu during 2012

Variety	Yield (t/ha)	Oil (%)	Protein (%)
CB Atomic HT	2.79	43.4	19.6
CB Jardee HT	2.79	42.0	19.2
ATR Gem	2.77	46.3	17.5
ATR Stingray	2.66	43.8	19.9
Crusher TT	2.66	42.5	17.8
CB Henty HT	2.61	41.9	19.2
CB Junee HT	2.60	42.7	18.9
Hyola 656TT	2.54	46.2	17.9
ATR Snapper	2.53	45.9	18.5
Hyola 559TT	2.53	44.7	19.7
Thumper TT	2.52	44.8	19.1
Hyola 555TT	2.51	43.3	19.1
CB Nitro HT	2.49	44.4	19.9
Jackpot TT	2.48	46.3	17.8
Monola 413TT	2.44	43.6	19.8
CB Sturt TT	2.34	43.1	19.7
ATR Cobbler	2.28	42.4	19.4
Monola 506TT	2.27	43.9	19.3
Monola 605TT	2.27	41.7	20.2
Bonanza TT	2.04	43.4	20.2
Sown	4 May 2012	**pH($CaCl_2$)**	4.9
Harvested	16 November 2012	**GSR (Apr-Oct)**	243
Site mean (t/ha)	2.53		
CV (%)	5.0		
F prob	<0.001		
LSD (t/ha)	0.21		



TABLE 22 Long-term predicted yields of faba bean varieties in north east Victoria 2005–12

Variety	Predicted yield (t/ha)	Site years
PBA Rana	2.41	5
Doza	2.46	4
Nura	2.49	7
Fiord	2.54	4
Cairo	2.57	3
Farah	2.59	7
Fiesta FV	2.62	7

TABLE 23 Yield and quality of faba bean varieties at Dookie during 2012

Variety	Yield (t/ha)	100 seed weight (g/100 seeds)	50% flowering day
Fiesta VF	3.78	57.7	234
Nura	3.46	49.8	236
Farah	3.19	56.1	231
PBA Rana	3.00	72.0	236
Sown	9 May 2012	**pH($CaCl_2$)**	5.2
Harvested	29 December 2012	**GSR (Apr-Oct)**	205
Site mean (t/ha)	3.52		
CV (%)	8.4		
F prob	<0.001		
LSD (t/ha)	0.48		

TABLE 24 Long-term predicted yield of lupin varieties in north central Victoria during 2005–12

Variety	Predicted yield (t/ha)	Site years
Mandelup	1.54	6
Jenabillup	1.52	6
PBA Gunyidi	1.51	3
Coromup	1.44	6
Wonga	1.33	6
Jindalee	1.29	3

TABLE 25 Yield and quality of lupin varieties at Diggora during 2012

Variety	Yield (t/ha)	100 seed weight (g/100 seeds)	Height (cm)	50% flowering day
Mandelup	1.96	15.5	54	252
Jenabillup	1.95	15.2	46	256
Coromup	1.78	14.6	48	257
PBA Gunyidi	1.59	13.8	49	256
Wonga	1.40	13.6	49	255
Sown	11 May 2012			
Harvested	13 December 2012	**pH($CaCl_2$)**	5.1	
Site mean (t/ha)	1.77	**GSR (Apr-Oct)**	206	
CV (%)	8.3			
F prob	<0.001			
LSD (t/ha)	0.23			

Canola — the economics and physiology of the timing of windrowing

Kathi Hertel
NSW DPI

Key points

- A better understanding of canola growth stages will allow growers to make informed practical and economic harvest management decisions.
- Understanding the term 'colour change' is crucial to avoid potentially significant crop and economic penalties. Seed colour is directly related to seed maturation.
- Maximum seed weight and oil content has been reached when seed moisture content has declined to 40%.
- The optimal time to windrow canola to maximise yield and oil content is when 40–60% of seed has changed colour. Seeds in the pods at the top of the main stem can be green but are firm when rolled between the thumb and forefinger.
- Under favourable spring growing conditions during the last few days leading up to the recommended windrowing time, canola can increase yield by 100kg/ha per day and oil content by between 0.3% and 0.6% per day.

Background

Windrowing is a standard operation in canola production in Australia. The expansion of canola into more marginal areas, the increasing frequency of below-average seasonal conditions and a closer focus on the economics of all facets of crop production have contributed to greater interest in direct heading crops and discussions surrounding canola harvest management.

During 2009, the widely different views and opinions regarding windrowing became apparent, including timing and effects on both oil and yield, subsequent economic outcomes overall, and its operational importance and role in canola production. It was evident that original industry guidelines had been forgotten, re-interpreted or modified and many in the industry had a poor understanding of crop physiological processes.

Industry survey

Since 2009, a survey of industry participants including growers, agronomists and consultants, and windrowing contractors was carried out. The survey involved in-depth phone consultations, one-on-one interviews and questionnaires at field days and grower meetings. A total of 900 responses were recorded. The following data is based on the preliminary data set, with analysis yet to be finalised at the time of writing.

Respondents varied significantly in their perception of the optimal colour change percentage under which to start windrowing. Answers nominating a figure ranged between 10% and 100% seed colour change, with 13% of respondents not nominating a specific number (see Table 1).

Looking more closely, 48% of growers, 51% of agronomists and 40% of contractors nominated a figure within the industry guideline of 40–60% seed colour change. Together with respondents who had not nominated their position in the canola industry ('unknown' category) this amounted to 46% overall.

The survey included a series of questions to quantify the perceived outcomes from non-optimal windrowing timing. The question was designed to allow answers to be represented as oil and yield growth curves, revealing current understanding of crop physiology.

A scenario was described where a crop was growing with no limiting factors (including moisture, temperature,



TABLE 1 Percentage of respondents indicating optimum level of seed colour change to windrow canola

% seed colour change	Grower	Agronomist	Contractor	Unknown	OVERALL
> 80	3	2	1	4	**2**
61 – 80	26	22	21	28	**25**
40 – 60	48	51	40	29	**46**
20 – 39	9	11	13	15	**11**
< 20	4	1	4	4	**3**
No figure	10	13	21	21	**13**

NOTE: This is preliminary data with analysis still to be finalised.

nutrition, disease and weeds) and given optimum timing on a nominated day, oil levels were 42% and yield was 2.5t/ha. Respondents were asked to specify what the oil content and crop yield would be if windrowing occurred 3–4 days and 7–10 days earlier than the designated optimum day and 3–4 and 7–10 days later. It was reinforced to respondents that it was assumed there were no adverse factors impacting on the crop, such as wind and shattering.

Perceptions of the impact on oil content and crop yield with the timing of windrowing operations were diverse. For example, when asked about the impacts on crop yield and oil content of windrowing 3–4 days earlier than the optimum time, answers were mixed.

Perceptions about windrowing timing effects on final oil content included:

- little or no effect (remain at 42% oil)
- losses with oil content dropping as low as 10%
- gains in oil content ranging from 47% – 57%

Similarly, respondents expectations of early timing effects on yield included:

- losses amounting to 1.0t/ha
- gains of a further 0.5 t/ha
- no effect (maintain 2.5 t/ha) at all on final yield.

Answers to the perceived effects of windrowing 3–4 days later than the optimum time on oil content and crop yield included answers ranging from having little or no effect on either oil or yield, to losing oil to levels as low as 10% final oil content. At the same time other respondents believed there were possible gains in oil content totalling 60% (and in one instance 75%).

Views as to the effects on yield alone were just as varied – some respondents believed there would be little or no change to crop yield, others that there would be losses amounting to 1.0t/ha, while others believed the opposite — that there would be gains of an additional 1.5t/ha if windrowing occurred 3–4 days later than the optimum time.

Even larger differences in judgements were recorded in response to questions regarding a 7–10 day period either side of the optimum windrowing timing. This will be reported later during 2013.

Level of experience

Survey respondents included some of the early pioneers of the Australian canola industry. Experience ranged between 40 years and their first year of involvement with canola. Early indications of the data set show no strong relationship between the levels of experience and understanding of the optimum time to windrow, or its impact on oil content and yield. This will be reported later in 2013.

Earlier analysis of 140 phone survey respondents examining correlations with years of experience in the canola industry revealed there to be no significant difference in responses to oil and yield related to optimal windrowing time. The expectation of an increase in yield (from a baseline 2.5t/ha yield at the optimum windrowing time) with later windrowing timing, 7–10 days after the optimum, appears to be less with increasing years of experience (see Figure 1).

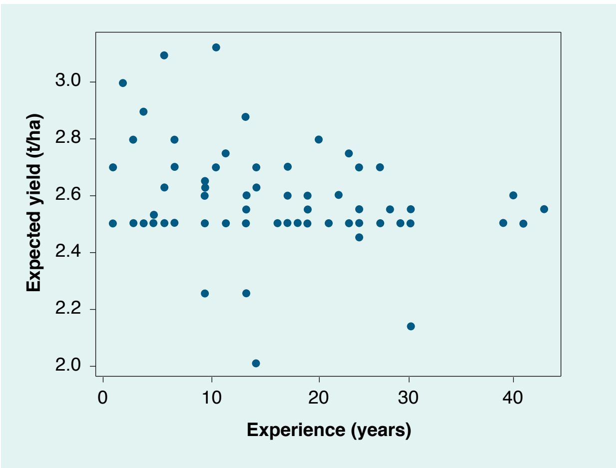

FIGURE 1 Canola industry experience and expected yield response to windrowing 7–10 days later than optimum

Optimal timing — industry standard

The optimal time to windrow canola to maximise oil content and crop yield is when 40–60% of seed on the main stem has changed colour. Seeds in the pods at the top of the main stem may be green but are firm when rolled between the thumb and forefinger.

This recommendation is based on research during the early years of the canola industry in Australia.

Colour change — what does it indicate?

Seed colour change reflects late stage physiological processes occurring in the plant involving oil synthesis and dry matter (DM) accumulation. While the seed is green, the seed is filling, accumulating weight, protein and oil.

The green seed starts to change colour when the seed reaches 50–55% moisture content. Seed dehydration is progressive, with simultaneous changing colour of the seed coat, darkening from green to red/brown to black. At the same time, the rapid phase of both seed weight and oil synthesis accumulation starts to slow and level out.

Physiological maturity occurs when the seed reaches the maximum seed DM accumulation. This is when maximum grain yield is achieved. In canola, this occurs at 35–40% moisture content. As moisture content falls below these levels, active seed metabolism ceases and the seed continues to dry down (dehydrate).

Seeds mature progressively up the main stem and from lower branches to the upper branches and ends of branches. Seeds in pods located on the lower main stem are the first to show signs of colour change — they are the most advanced and tend to be the most productive.

Does colour make a difference?

It is widely assumed that 'colour change" is a commonly-understood term. It became apparent from comments made during survey interviews and discussions, as well as specific questions, that the interpretation of 'colour change' is many and varied or just not implicit.

Some examples of both verbal and written responses referred to: "dark green", "just a speck", "speckled", "beyond the green", "red, "rusty", "maroon", "light brown", "brown smudge", "brown", "any colour", "bronze", "caramel", "not necessarily black", "jet black", "not black!" and "black".

The time period during which a seed has "just a speck" to "black" will vary with seasonal conditions. For example, under the favourable spring growing conditions in central west New South Wales during 2011, based on these descriptions, the considered views of survey respondents regarding their optimum time to windrow canola ranged somewhere within a period of 23 days at Gilgandra and 25 days at Wellington.

The decision to time operations such as windrowing and desiccation for direct heading based on the visible differences in seeds has a significant impact on crop outcomes. Using photographs and recorded observations, the impact of operations at times based on these descriptions is considerable (see Table 2).

Timing — what difference does it make?

Ideally, targeting windrowing operations to occur when 40–60% of seeds on the main stem have changed colour. Canola crops inherently vary in their time to reach maturity, influenced by prevailing seasonal conditions, aspect, soil type variations, sowing time, cultivar maturity and patchy establishment both within and between paddocks. Coordinating these factors with the availability of windrowers creates difficulties with matching practical issues with maximum crop performance outcomes.

TABLE 2 Canola crop value based on description of 40–60% seed colour change at Gilgandra and Wellington (2011)

Seed colour change description	Gilgandra			Wellington		
	Oil (%)	Yield (t/ha)	*Gross crop value ($/ha)	Oil (%)	Yield (t/ha)	*Gross crop value ($/ha)
Dark green	35.7	1.7	769.68	32.8	1.6	711.15
Speck of colour	37.7	1.8	841.95	41.3	2.5	1263.13
Bronze	42.3	2.2	1104.95	44.5	3.3	1711.88
Black	42.3	2.2	1104.95	44.5	3.3	1711.88
Difference						
(days)		*23*			*25*	
*Crop value ($/ha)^*		*335.27*			*1000.73*	

* Based on $500/t

^ Difference in crop gross value created by windrowing when seeds bronze or black' compared with dark green.



Anecdotal evidence frequently refers to windrow timing being several days “too early” or “too late” than desired. The wide mix of perceived consequences of these deviations highlights the poor understanding of physiological processes in canola during the later developmental stages.

The following data was collected from two trials at Gilgandra and Wellington in central NSW during 2011 — a season characterised by unusually ‘soft”’ spring growing conditions. The mild temperatures and excellent soil moisture levels allowed the canola to grow and develop with minimal environmental limitations.

One of the aims of the trials was to measure the rate of oil and yield accumulation in canola every 3–4 days, at the same time measuring the rate of seed colour change on the main stem of the plant. This allowed the impact of the timing of windrowing to be measured, comparing it to the industry recommended guideline of 40–60% seed colour change.

Trial design

Designs at each site were in randomised complete blocks with treatments within replicates spatially arranged using DiGGer to improve treatment neighbour balance. Ten plots (G) or 12 plots (W) were sown with four replications. Biomass sampling dates were randomly assigned to these plots.

Methodology

Sampling started less than a week after the end of flowering (GS69), 48 days (Gilgandra) and 40 days (Wellington) after the start of flowering. The number of sampling times totalled nine at Gilgandra and 12 at Wellington. Sampling took place every 3–4 days initially and every 5–7 days later. At each date a representative area containing about 25 plants (G) and 35 plants (W) was taken from the middle three rows.

Individual main stem raceme (flower spikes) from each plant were removed and divided into basal, middle and upper thirds. Processing was completed within eight hours of cutting.

Pods were removed from each of the raceme sections and seeds were removed and weighed from a 50-pod sub-sample. From each sub-sample 300 seeds were counted and weighed then dried for three days at 70°C before re-weighing. Seed colour at each date was recorded.

The remaining plant material was cut 20cm above ground level, placed in bags and air dried. It was then threshed and seed weight, seed size and seed quality including oil, protein, glucosinolates and moisture were determined. Seed quality data were determined and total oil content was calculated to 6% moisture.

Tables 3 and 4 show the results from the two trial locations, including changes in crop value at base prices of $400/t, $500/t and $600/t. Where analysed results showed no statistical significance, the median (i.e. middle) value was used. The percentage colour change refers to the average of seeds on the main stem.

These trial results support previous research findings, showing the significant yield and oil penalties, and potential economic losses that can occur when growers windrow canola earlier than industry guidelines.

During the favourable spring conditions of 2011, during the last few days leading up to the recommended windrowing time, the canola was increasing in yield by 100kg/ha per day and oil content by between 0.3% and 0.6% per day. The proportional change in economic value of the crop earlier than the optimum was similar at both sites.

Under less favourable finishing conditions, accumulation rates would be expected to be less and where heat and/or moisture stress is severe, the final stages of seed development may be prematurely brought to an end in some seasons. This will influence the practical and economic aspects of harvest management decisions, including the consequences of timing of either windrowing or direct heading.

Hybrids

A major change has occurred in canola production during the past decade with the advent of hybrids, at the expense of open-pollinated varieties.

The greater plant vigour of hybrids and lower targeted plant populations in many areas generates potentially more branching on individual plants. Within the hierarchy of branches and pods, seeds are at different stages of development; the potential of seeds is determined by their position within the plant canopy. Competition for assimilates between flowers on the same raceme, and between racemes on different branches, confer competitive advantages. This change in plant architecture with hybrids may affect the rate of seed maturity and hence visual signs in the crop, although no work has yet been done with them to see how they compare with open-pollinated varieties.

TABLE 3 Summary of crop data and dollar values at windrowing times – Wellington NSW (2011)

	7 days earlier	4 days earlier	Optimum date of windrowing	3 days later	10 days later
Date	**21 October**	**24 October**	**28 October**	**31 October**	**7 November**
Days after end flowering	28	31	**35**	38	45
% seed colour change	3	7	**41**	90	100
% seed moisture	54	49	**45**	37	24
1000 seed weight (g)	3.155	3.389	**3.942**	3.942	3.942
Yield (t/ha)	2.5	2.9	**3.3**	3.3	3.3
Oil (%)	41.3	43.4	**44.5**	44.5	44.5
Yield LSD (<0.05)	0.3				
Oil LSD (<0.05)	1.7				
Value of crop ($/ha)					
$400/t	989.5	1184.36	**1369.5**	1369.5	1369.5
Change in value ($/ha)	*– 380*	*–185.14*	***0***	*0*	*0*
(%)	*– 28*	*–14*			
$500 /t	1236.88	1480.45	**1711.88**	1711.88	1711.88
Change in value ($/ha)	*–475*	*–231.43*	***0***	*0*	*0*
(%)	*– 28*	*–14*			
$600 /t	1484.25	1776.54	**2054.25**	2054.25	2054.25
Change in value ($/ha)	*–570*	*–277.71*	***0***	*0*	*0*
(%)	*– 28*	*–14*			

TABLE 4 Summary of crop data and dollar values at windrowing times – Gilgandra NSW (2011)

	7 days earlier	3 days earlier	Optimum date of windrowing	3 days later	10 days later
Date	**30 September**	**4 October**	**7 October**	**12 October**	**17 October**
Days after end flowering	15	19	**22**	27	32
% seed colour change	3	13	**50**	75	97
% seed moisture	54	45	**43**	39	27
1000 seed weight (g)	2.548	3.052	**3.373**	3.549	3.549
Yield (t/ha)	1.8	1.9	**2.2**	2.2	2.2
Oil (%)	37.7	40.6	**42.3**	42.3	42.3
Yield LSD (<0.05)	0.4				
Oil LSD (<0.05)	2.7				
Value of crop ($/ha)					
$400/t	673.56	744.08	**883.96**	883.96	883.96
Change in value ($/ha)	*–210.40*	*––139.88*	***0***	*0*	*0*
(%)	*–24*	*–16*			
$500/t	841.95	930.05	**1104.95**	1104.95	1104.95
Change in value ($/ha)	*–210.40*	*––139.88*	***0***	*0*	*0*
(%)	*–24*	*–16*			
$600/t	1010.34	1116.06	**2054.25**	2054.25	2054.25
Change in value ($/ha)	*–210.40*	*––139.88*	***0***	*0*	*0*
(%)	*–24*	*–16*			

Conclusions

The data presented supports research carried out during the 1970s and 1980s that 40–60% seed colour change on the main stem is the optimum time to windrow canola.

The different crop architecture of hybrid canolas means that timing of windrowing in these situations warrants further investigation, especially in the hotter finishing conditions of northern NSW.

Further information

Windrowing is only one consideration when managing general harvest management. The Australian Oilseeds Federation in conjunction with NSW DPI, with funding by the GDRC has produced the *Canola Harvest Module* as part of the *Better Canola Technology Update* series.

A more comprehensive summary of canola growth and development, windrowing, direct heading and overall harvest management is available at: www.australianoilseeds.com/agronomy_centre/grower_guides

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Assessing the importance of phosphorus nutrition and alternative management strategies in wheat following canola

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Key points

- Visual phosphorus (P) responses were apparent early in the season and were reflected in the yield results.
- An application rate of 23kg P/ha was needed to achieve 95% maximum yield.
- While the site was highly responsive to applied phosphorus, it did not respond to sulphur (S) or zinc (Zn).
- Responses to post-emergent phosphorus applications were only significant where a low rate (4kg P/ha) was applied at sowing and with foliar applications at an early growth stage, limiting the potential for mid–late season top-ups.

Location: 8 km SE of Dookie, Vic

Rainfall:
Annual: 546mm
GSR: 360mm
Stored moisture: Full profile (341mm rain Jan-Mar 2012)

Soil:
Type: Red clay loam
CEC: 6.37
pH ($CaCl_2$): 4.9
Colwell P: 39
Deep soil nitrogen: 21kg/ha + expected 60kg/ha mineralisation
Organic carbon: 1.5%
Phosphorus Buffering Index (PBI): 70

Sowing information:
Variety: Wheat (Young)
Sowing date: 18 May 2012
Sowing rate: 80kg/ha
Fertiliser: Sowing: 60kg N/ha plus 20kg K/ha
In crop: 80kg N/ha
Sowing equipment: Cone seeder, knife point, press wheel
Treatments:

Row spacing: 29cm

Paddock history:
2012 — wheat
2011 — canola
2010 — wheat

Plot size: 20m x 1.74m

Replicates: 4

Aim

Evaluate wheat response to phosphorus (P) rate, product and tactical phosphorus applications.

Method

Three separate fertiliser treatment trials were established to evaluate the response of wheat to phosphorus at Dookie, Victoria during 2012:

1. Rates: nil, 4kg, 8kg, 16kg, 24kg, 32kg, 40kg P/ha was applied as MAP at sowing



2. Products: The following products were applied at rates equivalent to 16kg P/ha at sowing: Granulock Z, Granulock Z Extra, Granulock S, DAP, MAP, TSP, TSPS, EASY NP and competitor compound sulphur and zinc fertilisers (see Table 1)
3. Strategies: The following phosphorus application strategies were compared:
   a. Upfront MAP (4kg, 8kg, 16kg and 24kg P/ha).
   b. Upfront MAP (4kg and 8kg P/ha) plus Foliar EASY PK applied at 4kg and 8kg P/ha at tillering, jointing and both.
   c. Upfront MAP (8 kg P/ha) plus topdressed MAP applied at 8kg and 16 kgP/ha (tillering only).

The trial design comprised a completely randomised block design with 26 treatments and four replicates. Wheat (cv Young) was sown at 80kg/ha into sufficient soil moisture on 18 May, 2012 using a cone seeder with a knife point, press wheel system on 29cm row spacings.

Basal nitrogen (N) applied at sowing was balanced to supply the equivalent of 60kg N/ha (130kg/ha urea equivalent) and potassium (K) at 20kg K/ha (40kg/ha of muriate of potash (MOP) to all plots. A further 80kg N/ha (174kg/ha of urea) was topdressed on 13 August at tillering (GS22).

Non-limiting nitrogen rates were established based on deep soil test results of 21kg N/ha plus an estimated 60kg N/ha mineralisation (plus starter and topdressed nitrogen) for a total of 221kg N/ha. This was enough nitrogen (soil + applied) to achieve a wheat yield of 5t/ha at 11.5% protein.

The first foliar application of phosphorus (the 'early' timing) was applied on 20 August as EASY PK (1N:12P:24K %w/v) at 33L/ha or 67L/ha (4kg or 8kg P/ha) with a total water volume of 200L/ha using AI04 nozzles.

The MAP topdressing treatments (at 8kg or 16kg P/ha) were also applied on the 20 August at rates of 37kg and 73kg MAP/ha (8kg and 16kg P/ha).

For phosphorus rate treatments, dry matter (DM) and tissue samples were taken on 27 August and tiller counts on 12 September.

The second foliar application of phosphorus (the 'later' timing) was applied on 14 September.

The trials were harvested on 7 December using a small plot harvester.

Note: Crop growth stage at each application timing varied in response to rate of phosphorus applied at sowing, hence 'early' and 'later' timing refers to first and second date of application rather than 'tillering' and 'jointing' as described earlier in the method.

Results and discussion

Impacts of phosphorus rate

Phosphorus had a considerable effect on physiological growth stage and plant vigour. As a result, wheat shoot (tiller) counts for the phosphorus upfront treatments of nil, 4kg, 8kg, 16kg, 24kg, 32kg, and 40kg kg P/ha were assessed on a single date, when the 16kg treatment had reached stem elongation (GS31) (see Figure 1).

Shoot DM (kg DM/ha) increased with the amount of phosphorus applied (see Table 2, Figure 2). By 27 August the 40kg P/ha treatment produced significantly more DM than all but the 32kg P/ha treatment.

TABLE 1 Fertiliser product information

Product	Product description	Nutrient (%)
MAP	Monoammonium phosphate	10(N), 21.9(P), 1.5(S)
Granulock Z	Compound zinc sulphur product	11(N), 21.8(P), 4(S), 1(Zn)
Granulock Z Extra	Compound zinc sulphur product	11.6(N), 19.8(P), 5.4(S), 2(Zn)
Granulock S	Compound sulphur product	16(N), 16.7(P), 12(S)
DAP	Diammonium phosphate	18(N), 20(P), 1.6(S)
TSPS	Triple superphosphate + elemental S	19.6(P), 9.7%(S)
TSP	Triple superphosphate	20.7(P), 1(S)
Compound S	Compound sulphur product	12(N), 18(P), 10(S)
Compound S & Zn	Compound zinc sulphur product	12(N), 17.5(P), 10(S), 1(Zn)
Compound Zn	Compound zinc product	10(N), 22(P), 1.5(S), 1(Zn)
EASY PK	Ammonium phosphate solution	11(N), 16(P) w/v
Gran-Am	Sulphate of ammonia	20.2(N), 24(S)

Note: N = nitrogen, P = phosphorus, S = sulphur, Zn = zinc.

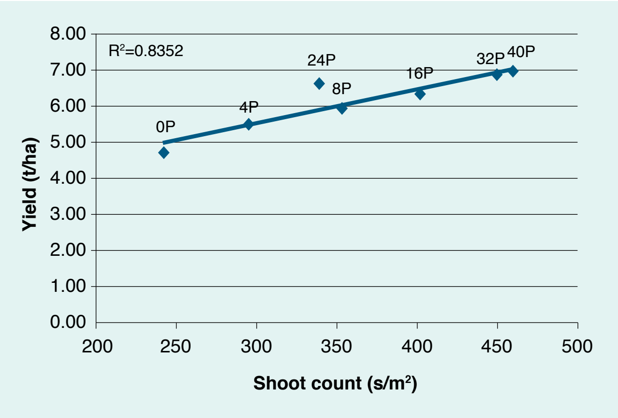

FIGURE 1 Wheat response to phosphorus application rate for corresponding yield and shoot counts

Early impact: the impact of phosphorus rate on early plant development is clear.

DM production in the 16kg P/ha treatment was significantly higher than the nil and 4kg P/ha treatments, but not the 8kg, 24kg or 32kg P/ha treatments. These results had a high CV%, suggesting caution be used when interpreting the results.

Similarly, tissue phosphorus concentration (P%) for wheat shoots increased with phosphorus rate applied (as shown in Figure 2). With the exception of the 4kg P/ha rate, the tissue phosphorus content of the control (nil applied phosphorus) was significantly lower than where phosphorus was applied. The phosphorus content of the 4kg, 8kg and 16kg P/ha treatments were not statistically different from each other, but were significantly lower than 24kg P/ha treatment. The application of 40kg P/ha resulted in a significantly higher tissue phosphorus concentration than all other application rates.

The 40kg P/ha treatment produced the highest tiller count (tillers/m²), however, this was not statistically different to the 16kg or 32kg P/ha treatments. There were no significant differences in tiller production between the

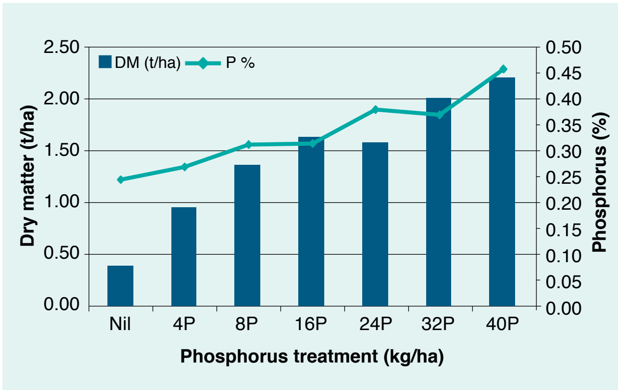

FIGURE 2 Wheat shoot dry matter and phosphorus uptake in response to application rate at stem elongation (GS31)

TABLE 2 Wheat response to phosphorus application rate for whole shoot dry matter, tiller number and tissue phosphorus, final yield and grain protein

Treatments	Dry matter (t/ha) 27/8/13		Tillers (no./m²) 12/9/13		Whole shoot tissue P (%)		Yield (t/ha)		Protein (%)	
Control	0.39	f	241.8	e	0.2475	e	4.70	e	11.9	a
MAP 4P	0.96	e	295.3	de	0.2725	de	5.46	d	11.8	ab
MAP 8P	1.37	ce	353.0	bd	0.3150	cd	5.92	cd	11.4	bc
MAP 16P	1.64	bc	401.7	ac	0.3175	cd	6.31	bc	11.2	cd
MAP 24P	1.59	bd	338.8	ce	0.3825	b	6.60	ab	10.8	d
MAP 32P	2.01	ab	449.6	ab	0.3725	bc	6.86	a	10.9	cd
MAP 40P	2.21	a	459.5	a	0.4600	a	6.90	a	10.7	d
LSD (P = 0.05)	*0.454*		*101.2*		*0.06*		*0.500*		*0.513*	
Treatment F Pr.	*<0.001*		*0.002*		*<0.001*		*<0.001*		*<0.001*	
CV%	*22.5*		*19.7*		*13.3*		*5.5*		*3.1*	



16kg P/ha rate and the 8kg, 24kg, 32kg or 40kg P/ha rates. Again, caution should be used when interpreting these results due to the high CV%.

There was a linear increase (R^2 = 0.835) in yield, in response to increasing phosphorus rates (see Figure 1). Yield of the 40kg P/ha treatment was similar to the 24kg and 32kg P/ha treatments, but was significantly higher than the nil, 4kg, 8kg or 16kg P/ha treatments. The 16kg P/ha treatment yielded similarly to the 8kg and 24kg P/ha treatments, but was yield significantly higher than the nil and 4kg P/ha treatments.

Grain protein levels declined with higher phosphorus application rates, however this could be attributed to insufficient nitrogen supply for the relatively high yields achieved in this trial (see previous calculations based on 5t/ha at 11.5% protein). This drop below 11% protein suggests the full expression of the phosphorus response at higher rates may have been limited by inadequate nitrogen supply.

Different soil types, crop rotations and climatic conditions can make it difficult to predict whether early shoot density, DM and tissue phosphorus concentration responses translate into yield at the end of the season. In this trial lower rates of applied phosphorus reduced crop biomass, tiller production, whole shoot phosphorus concentration and grain yield compared with plants receiving higher phosphorus application rates (see Table 2).

From the response curve plotted for this site (see Figure 3), an optimum rate of 23 kg P/ha can be extrapolated for 95% of maximum yield (6.55 t/ha). This assumes the phosphorus response was not limited by nitrogen supply.

Grain nutrient analysis indicated that the amount of phosphorus removed per tonne of grain ranged from 2.0kg to 2.4kg P/t, but did not differ significantly between application rates (see Table 3).

Phosphorus removal rates per hectare ranged from 9.6kg (nil treatment) to 14.7kg P/ha (40kg P/ha treatment). Phosphorus removal rates per hectare increased with the rate of phosphorus applied (in line with yield responses).

The 40kg P/ha treatment removed significantly more phosphorus than the nil, 4kg, 8kg and 16kg P/ha treatments, while the 24kg and 32kg P/ha treatments removed significantly more than the control (nil treatment). There was no difference in phosphorus removal between the nil, 4kg, 8kg and 16kg P/ha treatments.

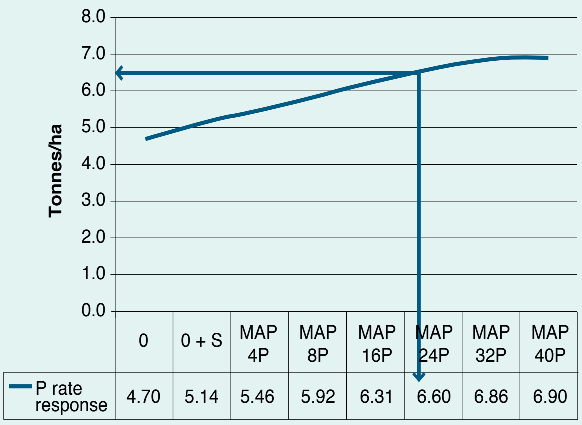

FIGURE 3 Phosphorus response curve (95% maximum yield)

Product response

Numerous options for cropping starter fertilisers are available, with the main considerations around nitrogen, phosphorus, sulphur and zinc content. With the exception of TSP (which was significantly lower yielding than the products marked with an 'a' or an 'ac' in Figure 4) and TSPS (which had significantly lower protein than products marked with an 'a' or 'ab' in Figure 4), there were no statistical differences between products when applied at the equivalent rate of 16kg P/ha (see Figure 4). There was also no response to additional sulphur or zinc fortified products.

The sulphur (MCP test) level for this site was 41mg/kg (high) and DTPA zinc soil test value was 0.46mg/kg (satisfactory). On acid soils zinc responses can be unpredictable but are generally seen in higher-yielding situations, on low soil zinc levels, recently limed soils and where sulfonylurea herbicides have

TABLE 3 Phosphorus removal rates from grain tissue analysis

Treatments	Grain P removal (kg P/ha)	Grain P removal (kg P/t grain)
Control	9.6	2.25
MAP 4P	11.2	2.28
MAP 8P	11.9	2.25
MAP 16P	11.3	2.00
MAP 24P	12.4	2.10
MAP 32P	12.8	2.10
MAP 40P	14.7	2.40
LSD (P = 0.05)	*2.4*	*0.403*
Treatment F Pr.	*0.024*	*0.722*
CV%	*14.6*	*13.2*

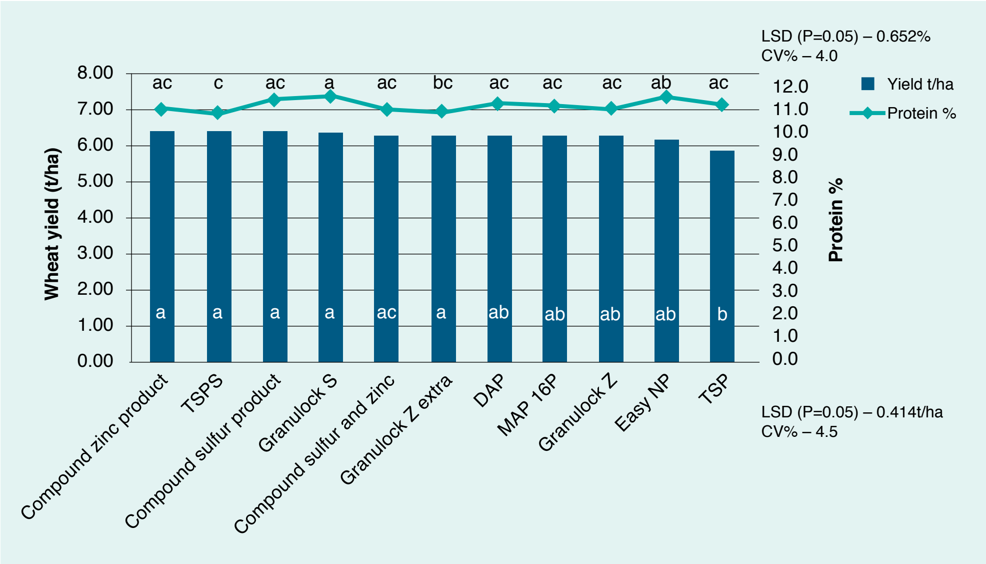

FIGURE 4 Wheat yield and protein response to various starter fertilisers

been used. The interaction of zinc and phophorus is antagonistic so higher starter rates of phosphorus or higher soil phosphorus levels can also play a role in zinc reponsiveness.

Impact of phosphorus strategy

Where only 4kg P/ha was applied at sowing (MAP 4kg P/ha), an early timing application of foliar phosphorus (which applied an additional 4kg/ha of foliar phosphorus as EASY PK) significantly improved wheat yields above the MAP 4kg P/ha treatment (see Table 4).

A late application of foliar phosphorus (4kg/ha foliar phosphorus as EASY PK) did not increase yields above the MAP 4kg P/ha treatment. There was no yield advantage in applying both the early and late foliar applications compared with the early application alone.

Where 8kg P/ha was applied at sowing (MAP 8kg P/ha), no statistically significant yield responses to any applications of foliar phosphorus or to topdressed MAP combinations (8kg or 16kg P/ha applied post emergence) were found.

TABLE 4 Post-emergent response to foliar applications of phosphorus

Treatments	Yield (t/ha)		Protein (%)	
Control	4.70	d	11.9	a
MAP 4P	5.46	c	11.8	ab
MAP 4P+Easy PK 4E*	6.10	b	11.5	ac
MAP 4P+Easy PK 4E+4L**	5.98	b	11.4	ac
MAP 4P +Easy PK 4L	5.45	c	11.4	ac
MAP 8P	5.92	bc	11.4	bc
MAP 8P+Easy PK 8E	6.14	ab	11.5	ac
MAP 8P+Easy PK 8L	6.26	ab	11.4	ac
MAP 8P+Easy PK 8E+8L	6.23	ab	11.6	ac
MAP 16P	6.31	ab	11.2	cd
MAP 8+MAP 8E	6.32	ab	11.1	cd
MAP 8+MAP 16E	6.18	ab	11.8	ab
MAP 24P	6.60	a	10.8	d
LSD (P = 0.05)	*0.481*		*0.504*	
Treatment F Pr.	*<0.001*		*0.004*	
CV%	*5.6*		*3.1*	

E – early application timing (Aug 20)L – later application (Sep 27)

There was no difference in yield between those treatments that received a total of 16kg or 24 kg P/ha, providing at least 8kg P/ha of the total phosphorus application was received at sowing. This was irrespective of whether the whole amount was applied as upfront MAP, or as 8kg p/ha MAP plus foliar EASY PK or topdressed MAP.

Tactical phosphorous applications aim to minimise phosphorus expenditure at sowing and allow for strategic applications of additional phosphorus when seasonal conditions are more apparent (similar to nitrogen management). While foliar phosphorus application results indicate there is the potential for topping-up phosphorus during the season, (through leaf and possibly root uptake), the efficacy and economics of adapting this strategy require further evaluation.

Acknowledgements

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Controlling flaxleaf fleabane

Simon Craig
BCG (Birchip Cropping Group)

Key points

- Trials have revealed that Roundup® alone will not control flaxleaf fleabane.
- The addition of Surpass® and Ally® to Roundup provided the most effective control.
- It is critical to control fleabane before it starts to elongate (>40cm in height) to reduce control costs.

Location: Kooloonong (170km north of Birchip)
Spraying date: 4 November 2012
Paddock history: Medic fallow (brown manured)
Plot size: Main herbicide plots (2.5m x 40m)
Sub-plots (2m x 2.5m)
Replicates: 3

Background

Flaxleaf fleabane (*Conyza bonariensis*) is a major weed in cropping areas across southern Queensland, northern New South Wales and more recently northern Victoria.

Fleabane is a prolific seeder: a mature plant can produce more than 100,000 seeds. These seeds are air-borne (spread by wind) and can infest large areas in a short period of time.

The relatively cool (25–30°C) wet harvest during 2012 stimulated fleabane germination roadsides and in uncropped land during October and November. From these areas it spread to nearby paddocks.

Fleabane is particularly difficult to control in no-till farming systems, principally due to heavy reliance on glyphosate (particularly with high stubble loads.

No-till, glyphosate-based fallows are at greatest risk of fleabane incursion because fleabane populations have developed tolerance or resistance to glyphosate.

Seeds prefer to germinate at temperatures less than 20–30°C (optimum 25°C), often experienced during spring and autumn, and moist conditions and only when they are on or close to the soil surface. A study has found that when seeds are buried deeper than 10cm, emergence is significantly reduced, but seed dormancy can last from 18 months to six years.

After germination, particularly during winter, though fleabane growth may appear slow aboveground, beneath the soil surface the weed is establishing a deep tap root. By spring and early summer, the plants can be two to three months old, at which stage they are extremely difficult to kill.

The recently-funded GRDC project *Emerging weeds in southern Australia*, led by the University of Adelaide, in partnership with the BCG (Birchip Cropping Group) is investigating new methods and products to control difficult weeds.

The project will also look at other weeds such as windmill grass, hairy panic, couch and brome grass.

Aim

To determine the most effective herbicides for controlling flaxleaf fleabane.

Method

Using a matrix design, 15 herbicide treatments were applied in a randomised block design. On 4 November 2012, the treatments listed in Table 1 were applied, using a gas-pressured five-nozzle shielded sprayer (see Table 2).

The fleabane plants varied in size at the time of spraying, ranging from just 4cm in height to well branched and beginning to bolt.

The population was relatively low: density was recorded at less than two plants per square metre.

Plants were visually assessed for herbicide efficacy scores 7, 18 and 25 days after application (DAA).

The ratings were based on a scale of 0 (alive) to 100 (dead).

Results

Germination occurred during early October, after late September rainfall. Following the treatment applications on 4 November 2012, herbicide efficacy scores taken at 7, 18 and 25 days after application (DAA) showed that increasing the rate of glyphosate (Roundup) did not improve control of fleabane (see Table 3).



TABLE 1 Products and mixes flaxleaf fleabane control trial

Description/product	Rate (per hectare)	Cost ($)
Untreated		0
Roundup PowerMax	1.0L	5.75
Roundup	PowerMax 2.0L	11.50
Roundup PowerMax	3.0L	17.25
Roundup PowerMax	5.0L	28.75
Roundup PowerMax + Surpass 300	2.0L + 1.6L	16.46
Roundup PowerMax + Surpass 300 + Ally	2.0L + 1.6L + 5g	16.86
Roundup PowerMax + Ally	2.0L + 5g	11.90
Roundup PowerMax + Hammer® (240g/L)	2.0L + 75ml	33.45
Roundup PowerMax + Lontrel®	2.0L + 150ml	16.00
Roundup PowerMax + Tordon® 75-D	2.0L + 700ml	n/a
Roundup PowerMax + Balance®	2.0L + 100g	48.83
Note: treatments were sprayed east to west. Li700 was added to each mixture at 300ml/ha.		

TABLE 2 Weather conditions at the time of spraying

Spray details	Treatment application
Date	4 November 2011
Implement	Gas pressure 2.5m sprayer
Water rate	100L/ha
Nozzles	AIXR110-02
Boom height	70cm
Temperature	27ºC
Wind speed	6km/hr
Direction	Southerly
Humidity	50%
Delta T	8

Glyphosate effects were observed 7 DAA, but by 25 DAA, the effect was negligible.

The addition of other products with different modes of action significantly improved the effect of glyphosate.

Surpass and Tordon were the most effective products used in combination with glyphosate. The addition of Ally to the Surpass mix appeared to improve control slightly. Ally alone provided reasonable control up to 25 DAA.

Group G chemicals (for example, Hammer) were the least effective herbicides. Typically used as 'spikes' to improve control with glyphosate, they were effective only early. The effect of Hammer was observed with necrotic spots

TABLE 3 Herbicide efficacy scores (10 = alive, 100 = dead) for the main herbicide plots (or sub-plot A) at 7, 18 and 25 days after application (DAA)

Treatment	Fleabane control (%)		
	7 DAA	18 DAA	25 DAA
Untreated	10	10	10
Roundup PowerMax (1L/ha)	40	20	15
Roundup PowerMax (2L/ha)	40	20	20
Roundup PowerMax (3L/ha)	45	25	30
Roundup PowerMax (5L/ha)	45	40	30
RupPMax (2L/ha) + Surpass (1.6L/ha)	60	50	80
RupPMax + Surpass + Ally (5g/ha)	60	50	85
RupPMax + Ally	50	40	50
RupPMax + Hammer (75ml/ha)	60	30	20
RupPMax + Lontrel (150ml/ha)	60	45	35
RupPMax + Tordon (700ml/ha)	65	60	70
RupPMax + Balance (100g/ha)	60	65	50
Sig. diff.	*P<0.001*	*P<0.001*	*P<0.001*
LSD (P=<0.05)	*5*	*10*	*20*
CV%	*6%*	*16%*	*35%*

on the leaves, but overall the plant remained healthy. Given that glyphosate had failed to kill the weed, the plants subsequently regrew. By the 25 DAA assessment, those plots were healthy and setting seed.

On-farm implications

Flaxleaf fleabane is a weed that needs to be controlled. Control is expensive and can be difficult during harvest.

Given the right conditions, this weed has the potential to be two to three months old before farmers are aware of its existence and realise control is required. Figure 1 below illustrates the effectiveness of both single and double-knock strategies.

The single strategy controlled, at best 60% of the weed population. Where a second (double-knock) application was carried out, it controlled 90–100% of the weed plants — even at three months of age.

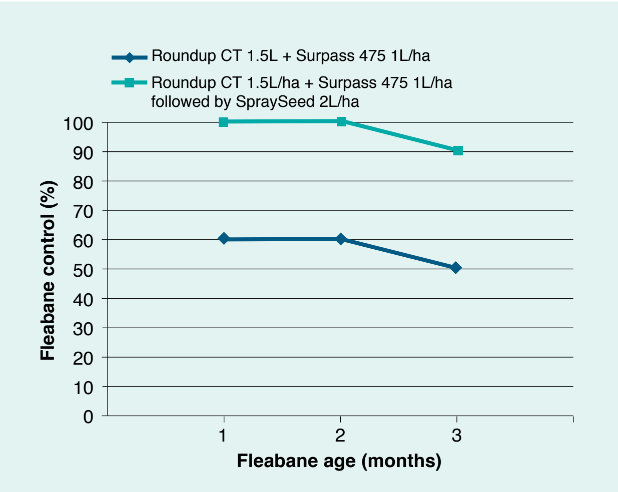

FIGURE 1 Benefit of double-knock over single herbicide applications on fleabane control (DEEDI 2009)

Note: First application applied at 75 L/ha, second application at 105 L/ha (applied seven days after first knock for all timings)

By not applying a second application, the remaining 40% had the potential to produce a huge number of seeds. By committing to a second spray and taking a zero tolerance to fleabane, populations are more likely to remain manageable.

If fleabane is found on paddocks, even along fencelines, it warrants control

Though the double-knock strategy has not been reported in this trial, other studies on fleabane have found the practice to be very successful. Fleabane has been extensively studied in NSW.

The findings of the first application reported in this trial were similar to the NSW experience mentioned above in that Roundup alone provided little control.

In the current trial, higher rates of Surpass were found to be the most effective and, where the rotation permitted, Ally provided some residual control.

Despite control being improved, it was still not effective enough and a follow-up application would have been required.

NOTE: SpraySeed is not currently registered for the control of fleabane. Until a permit is issued a use pattern specifically targeting fleabane should ***NOT*** *be carried out.*

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Economic analysis of soil pH management using variable rate technology

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Key points

- Variable rate technology (VRT) has been used to manage several agricultural activities for some time.
- This project explored the input cost benefits of adopting variable rate management of soil pH.
- The cost analysis showed substantial savings in pH management could be possible by adopting VRT.

Aim

The common practice to address low soil pH is to apply a blanket rate of lime, which does not take into consideration the variance of pH within the targeted area. Blanket rate application is simple, but leads to over-application of lime across some areas of the paddock. This project explores the input cost benefits of variable rate technology (VRT) when used in conjunction with soil pH mapping.

Method

A 40ha trial was located on the Fitzgerald property at Berrybank, 60km southwest of Geelong. The paddock has sandy clay soils and was mapped with a grid soil sampling pattern imposed over the paddock using Office Farm Works software. A soil sample was taken to a depth of 0–10cm at each grid location, using a GPS navigation system, an all terrain vehicle and laboratory analysis equipment. These samples were sent to a commercial laboratory for pH analysis.

Based on the soil pH analysis results, a simple cost comparison for two scenarios was explored.

The first scenario used a conventional approach of determining the average pH of the paddock soil from samples across a diagonal transect of the paddock and determining a blanket lime application rate for the paddock. The second scenario developed a pH variability map of the paddock, subdivided the paddock into appropriate management zones and then determined the lime application rate for each zone based on the systematic soil sampling strategy.

Results

The paddock pH map (see Figure 1) identified five pH zones of varying geometry.

The resulting analysis identified that two of these zones did not require lime, while the other three zones required a total combined lime application of 28.49 tonnes across the three zones (see Table 1).

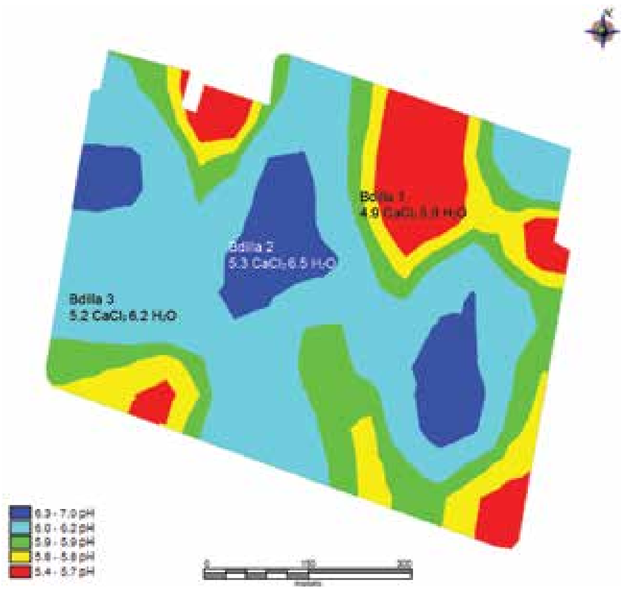

FIGURE 1 pH variability map, showing five pH 'zones'

TABLE 1 Average pH of the mapped zones with estimates of required lime application

pH ($CaCl_2$)	Zone area (ha)	Lime application rate required (t/ha)
5.5 – 6.2	4.85	No application required
5.2 – 5.4	18.97	No application required
5.1	7.21	1.5
5.0	4.48	1.5
4.6 – 4.9	4.38	2.5
Total	**40.00**	**28.5**

TABLE 2 Cost analysis of blanket lime application compared with variable rate lime application

Item	Cost ($/unit)	Blanket application scenario ($)	Variable rate application scenario ($)
Lime	$18.90 per tonne	1890.00	538.00
Freight	$15 per tonne	1500.00	427.00
Soil tests – blanket rate	$4.00 per ha	160.00	n/a
Soil tests – variable rate	$7.00 per ha	n/a	280.00
Total costs		**3550.00**	**1245.00**

The conventional blanket rate application, based on soil samples taken about every 50m on a diagonal transect across the paddock, returned an average pH reading of 4.6 ($CaCl_2$). The conventional approach based on these results would result in 2.5t/ha (100 tonnes total) of lime being spread across the whole paddock.

The resulting cost analysis is shown in Table 2.

Observations and comments

This simple analysis shows that variable rate management of soil pH, using VRT, could reduce input costs significantly.

This analysis has not included the costs of implementing VRT in the lime application system; however many farmers and contractors have invested in this technology for other purposes already.

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Notes

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