RiverinePlains

Research for the Riverine Plains 2012

A selection of research relevant to agriculture in the Riverine Plains

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Research for the Riverine Plains 2012

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
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Contents

INTRODUCTION

RIVERINE PLAINS INC — RESEARCH AT WORK

RESEARCH RELEVANT TO THE RIVERINE PLAINS

Area covered by Riverine Plains Inc

Membership area



2012 Riverine Plains Inc Committee

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Units of measurement

Row spacings

A number of trials carried out during 2011 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

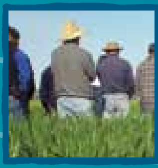
kilojoules — kJ

litres — L

metres — m

millimetres — mm

tonnes — t.



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.

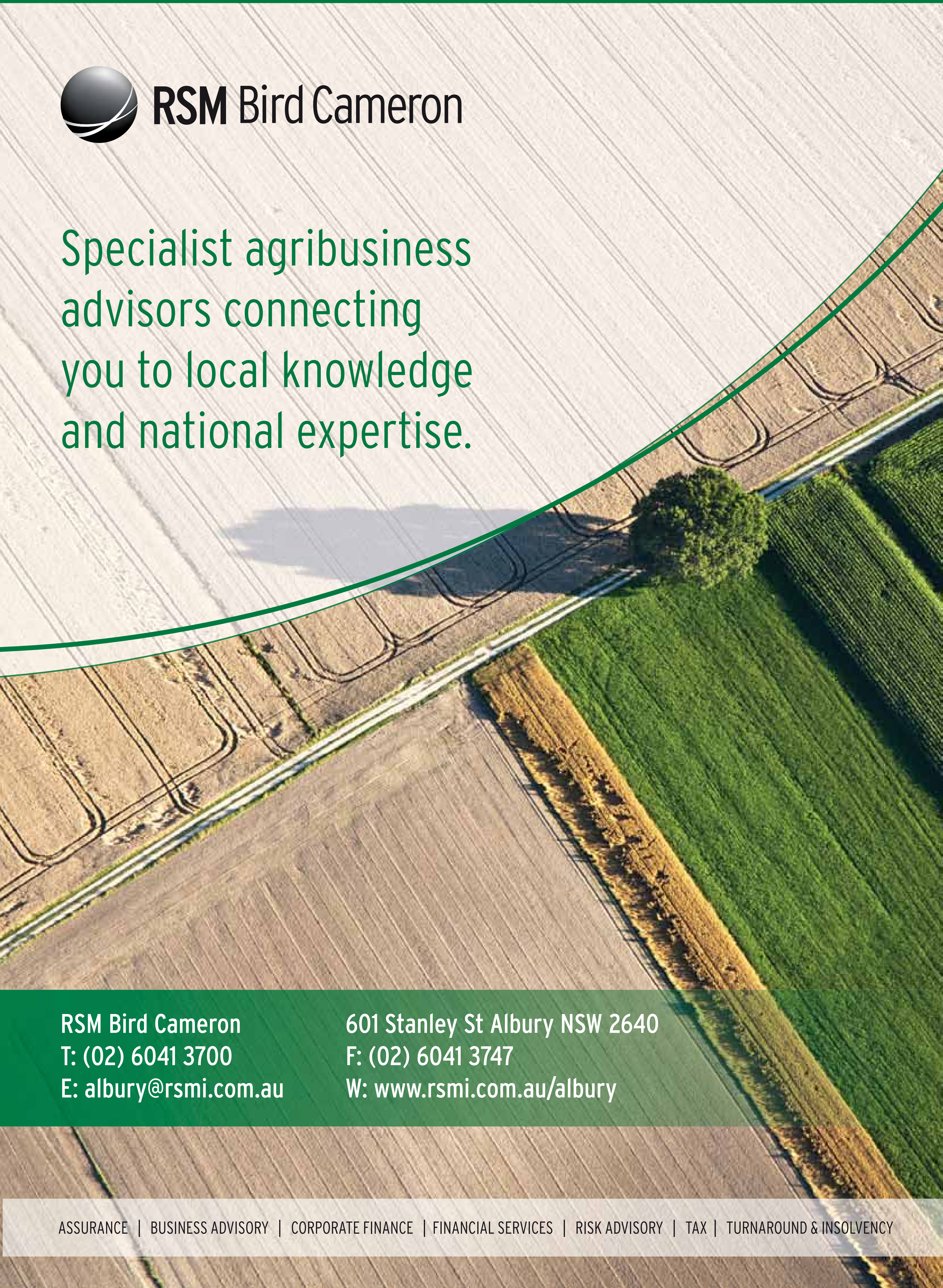
TABLE 1 Example of a replicated trial with four treatments

	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.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A word from the 2011 Chairman

Andrew Russell
Chairman 2010–11

Another year and another set of challenges

Reflecting on 2011, I realise that as growers we had plenty to deal with and manage.

The 2010 harvest was one of the most trying we have experienced in the Riverine Plains, with unprecedented rainfall during the harvest period causing widespread damage and downgrading. This, on top of the three to four previous drought seasons, left a huge number of Riverine Plains growers simply exhausted.

This unique combination of events presented many challenges for our members and the Riverine Plains Inc Committee immediately set about identifying the resulting issues that would be of concern. This early focus enabled us to put together another huge portfolio of events during 2011, which helped growers make some of their difficult decisions.

Our events calendar started with the GRDC update during February, where a solid program and high-quality speakers saw a fantastic turnout of more than 160 growers attend.

March was all about the challenges of sowing and setting up for another growing season. Riverine Plains Inc, along with Murray CMA, hosted Bill Crabtree on stubble management. This was then followed by the SPAA Precision Ag workshops, a Summer Forage field day and an Integrated Weed Management workshop.

As most growers are aware these days, the business aspect of farming is becoming more and more complex and important within all farming businesses. During July, Riverine Plains Inc, together with our platinum sponsors NAB and RSM Bird Cameron, hosted a business update, which covered topics including commodity price outlooks, global economic review and steps you can take to keep the income you receive.

During July we also hosted a pre-emergent herbicide paddock walk with Dr Chris Preston looking at the Bundalong integrated weed management site. The day addressed pre-emergent chemistry, stubble management and other agronomic challenges.

One of the major issues that growers faced during the 2011 growing season was the mouse plague and the devastating effect they were having on crops. This topic was a feature of the in-season update at Mulwala during August. Another highlight of the in-season update was Nick Poole's presentation, which covered row spacings, water use efficiency and canopy management. There were also other presentations, which covered many of the issues facing growers at that time.

During August Riverine Plains Inc hosted a Soil Carbon workshop in Yarrawonga, which included a comprehensive presentation from Clive Kirkby on growing soil humus as a "crop" to potentially increase economic productivity. This was then followed by a visit to two local growers to look at this concept in practice.

August continued to be a busy month for the group because we also hosted a bus trip into central New South Wales where members visited inspiring fellow farmers in Darlington Point, Griffith, Condobolin, Nyngan and Warren. The tour group looked at many different farming businesses and how they were adapting or expanding within the environment they worked in or the other opportunities they had pursued.

During early September Riverine Plains Inc hosted its spring field day at the Coreen trial site. This was an extremely well attended day by both growers and agribusiness representatives. The day featured, among other things, discussions on crop establishment, disease management, nutrition and seed-bed utilisation. A great open discussion was also had about the various issues growers were facing at that point in the season.

As a lead-up to harvest, Riverine Plains Inc, as part of its commitment to precision agriculture (PA), hosted workshops on yield mapping. This provided an opportunity for growers to attend and update their skills with representatives from all of the current service providers in attendance.

Behind the scenes there was also plenty happening within the Riverine Plains Inc committee itself. During June, the committee participated in a strategic planning workshop. This was facilitated by Tony Kent to look at the long-term and short-term challenges faced by the group in relation to membership and the sustainability of the committee and how it functioned. This was a great learning process for all and has given the committee some great direction for the future. As a direct result of that workshop, it was decided to appoint a Project Officer during November to assist with the research projects within the Riverine Plains Inc portfolio. This, in my opinion, is a great step forward. The committee also developed an annual members' survey to identify issues that need addressing and ideas for future research or events. This was issued to members during March 2012.

Farming these days is challenging to say the least. Riverine Plains Inc plays such a crucial role in constantly looking forward to the issues at hand, prioritising local research and providing opportunities for peer-to-peer learning, networking and fellowship. All these ingredients can make a huge impact on how we face the challenges of the future and importantly, how we can all best remain sustainable and profitable.



A word from the incoming Chair

Evan Ryan
Chairman 2012

As incoming Chairman of Riverine Plains I am very thankful to the two immediate past Chairmen Andrew Russell and Adam Inchbold. These gentlemen have laid down a foundation of co-operation and goodwill with sister groups and funding agencies and their legacy is a committee structure that ensures our group can achieve and propel itself into the seasonal challenges and research priorities of the broadacre farming sector with conviction.

I am sure our membership can relate to the farming business as being an all-consuming occupation especially as seasonal demands stretch our limited physical and mental resources to exhaustion at times. However our communities require us to volunteer and contribute to our industry and this contribution is both rewarding and broadening, and I would invite you as a member to actively consider contributing to your local group, such as Riverine Plains, in research or extension.

To introduce myself to the broader membership I have been fortunate to be involved with many groups of farmers since finishing university. Working in the Wimmera and Mallee regions of Victoria in the DPI grains team, followed by some commercial agronomy experience, I returned full time to our family's farm near Yarrawonga, soon after which I became a Riverine Plains committee member. Since returning home I also have had the honour of completing a Nuffield scholarship during 2010 where I researched a pet topic of trace element nutrition while travelling extensively abroad.

During my time back in the family farm business with my parents John and Helene I also married my wife Therese who works in education in the local area. We live a great life in the local farming area despite the challenges that are inherent in the sector in which we all operate.

As a farming business that has been a member of Riverine Plains from its inception and becoming an active member of the committee several years ago, it is an honour to be of service to the group in a senior leadership role.

Our research compendium needs little introduction to our members who have been with us through the years. Not only does it report on current research from within our own organisation, it brings forward and publishes the best from relevant partners in our industry. Many hours of meticulous work by our staff and contributors enable us to present this to you and I would like to thank all those individuals and organisations who have contributed articles and the sponsors who make the publication possible. We particularly recognise the ongoing support provided by the GRDC which enables locally-based research to continue.

Riverine Plains is proud to bring you the latest project results from the *Water Use Efficiency* research project. There have been many contributors to this project both in terms of managing the project and in writing up each year's results. I would especially like to thank Nick Poole and Tracey Wylie from the Foundation for Arable Research Australia and John Seidel, Mark Harmer and Adam Inchbold for their work in preparing this important work for publication.

Riverine Plains has also partnered with several other organisations, including CSIRO, Precision Agriculture Australia, The University of Adelaide and the *Grain & Graze 2* project team on recent projects and we are also pleased to bring you their results.

I would like to thank Fiona Hart, Allison Glover, Michelle Pardy, Dale Grey (DPI Victoria) and NSW DPI staff Lisa Castleman and Janet Walker for their work in collating the book and ensuring it meets the high standards expected by our membership. Thanks also to Janet Paterson and Catriona Nicholls from Hot Tin Roof Communications for editing the articles, liaising with authors and working with designer Josephine Eynaud from Redtail Trading to produce the finished result.

The trial book is an annual milestone for the group and a major achievement. I hope you enjoy the many gems of information in these pages and we look forward to your feedback and comments throughout the 2012 season.

2011 — the year in review

Janet Walker
NSW DPI, Albury

The summer of 2010–11 was wet and mild with very high rainfall during late February across the district. Rain during mid April provided some opportunity for sowing crops on time with the next opportunity arriving with rain towards the end of May, which allowed the remainder of crops to be sown on time. June was dry with limited growth. Rain during July and August set yield potentials up well.

The good rain during July and August was followed by some dry, hot conditions, however the spring rain was generally adequate to maintain yield potential. Winter crop growth was vigorous despite the relatively low growing season rainfall, due mainly to the full profile of moisture following the wet summer.

Monthly maximum temperatures for early autumn and winter and spring were below average (see Figure 1). This continued until June, when temperatures dropped with drier conditions. The moist conditions through most of the season led to fewer frosts during winter and spring and enabled good growth rates. Minimum temperatures were above average for the season with the exception of May, which had fewer wet days.

Annual rainfall for 2011 was impressive but was mainly due to a very wet February. Growing season rainfall was well below average across the district. Total rainfall for the year was in decile eight and nine (see Figures 5 and 6) with 878mm for Albury and 834mm for Corowa (see Figures 3 and 4). The cumulative growing season rainfall for Albury and Corowa was decile four and five respectively (see Figures 7 and 8).

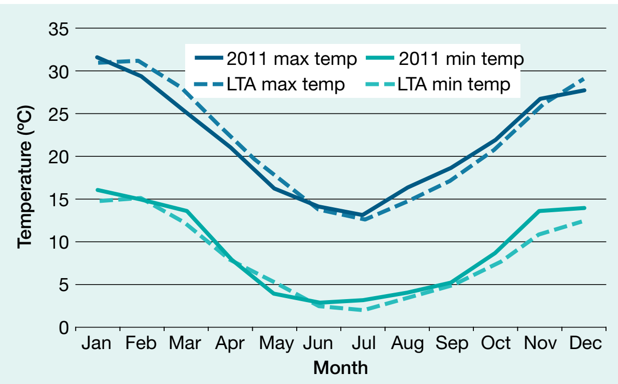

FIGURE 1 Minimum and maximum temperatures for 2011, compared with long-term averages (LTA)

Cropping

There were some changes to crop plantings compared with previous seasons. An increase of 10–15% in the area sown to canola was at the expense of triticale and pulse crops and a slightly lower area of wheat. This was partly due to the strong market conditions for canola and the need for a break crop following wheat on wheat during drier seasons.

Following the wet February, subsoil moisture conditions were excellent. Many grazing crops were sown early or on

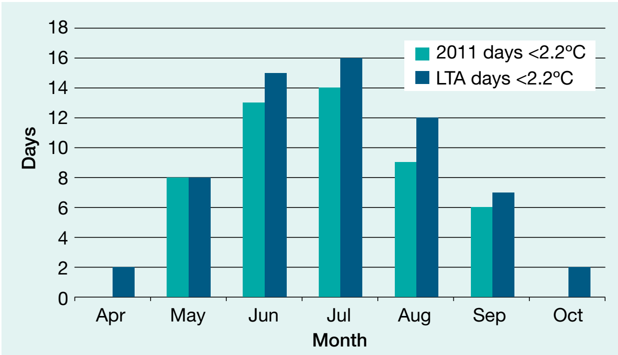

FIGURE 2 Frosts in Albury 2011 compared with long-term averages (LTA)

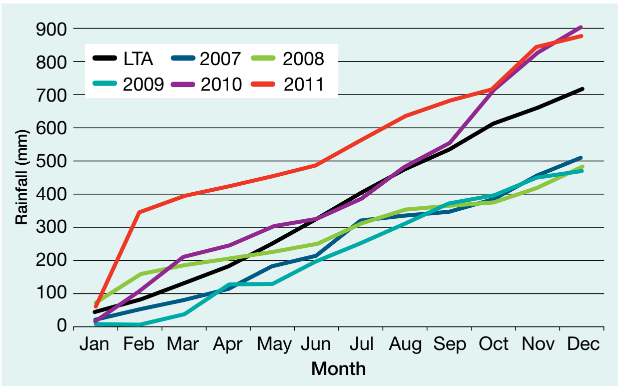

FIGURE 3 Cumulative rainfall Albury

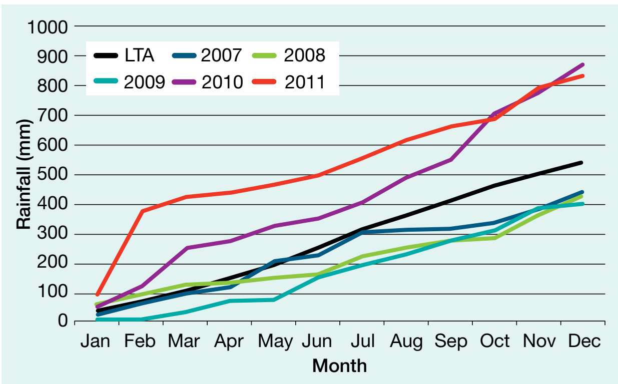

FIGURE 4 Cumulative rainfall Corowa

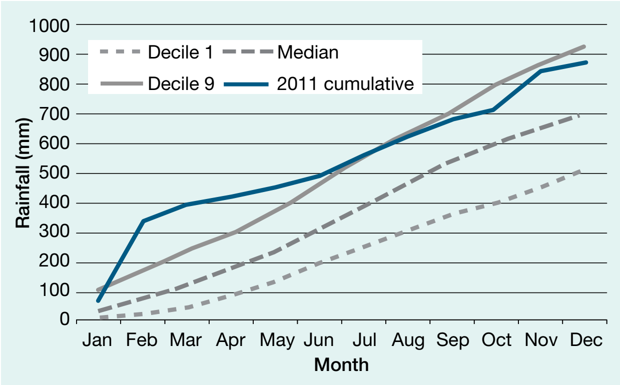

FIGURE 5 Cumulative rainfall at Albury 2011 against decile 1, median and decile 9

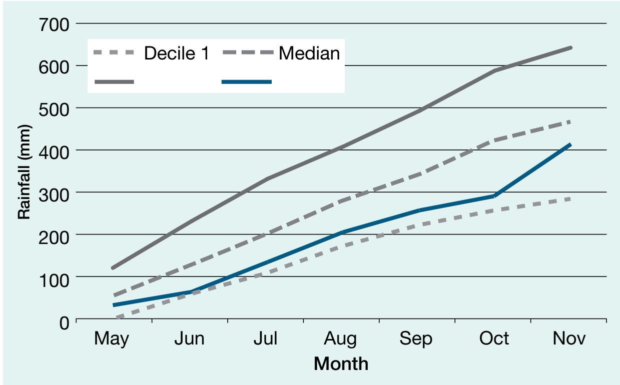

FIGURE 7 Cumulative growing season rainfall at Albury 2011 against decile 1, median and decile 9

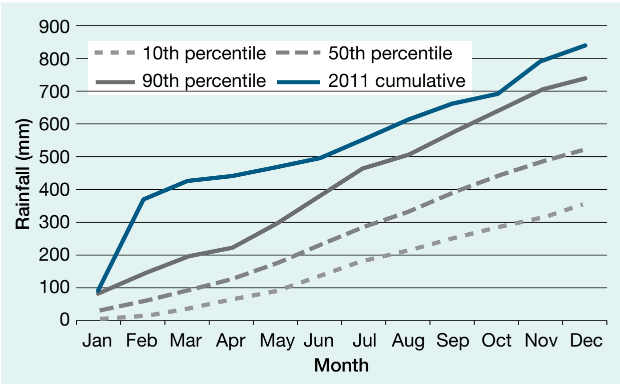

FIGURE 6 Cumulative rainfall at Corowa 2011 against 10th, 50th and 90th percentile

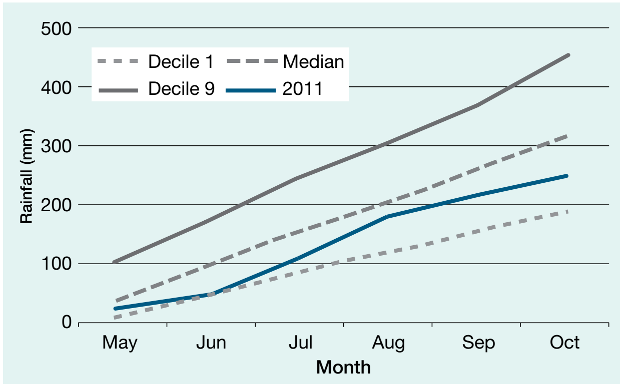

FIGURE 8 Cumulative growing season rainfall at Corowa 2011 against decile 1, median and decile 9

time with vigorous early growth. Rain during mid April and the end of May allowed other crops to be sown on time.

Most crops established well. High 2010 stubble volumes resulted in more stubble burning than during previous seasons. The main establishment issue was mice with widespread monitoring and baiting across the district. Mouse numbers and damage were higher on the western side of the district with some crops needing to be re-sown. Mice activity was generally lower in the Albury district compared with other parts of the state, particularly later in the season towards harvest.

The drier autumn and below-average June rain reduced the vigour of late-sown crops and led to many grazing crops only being grazed once. Good rainfall during late winter and into spring improved conditions and allowed for a timely top-dressing. Deep soil nitrogen tests generally indicated low soil nitrogen and high top-dressing rates were required following the 2010 yields. Top-dressing rates of up to 70–90kg nitrogen/ha were not uncommon. However given market conditions and other financial considerations, many crops did not receive the required rates of nitrogen. By September 2011 the season was shaping up to be an average to above-average season in terms of grain yield.

Disease issues

Foliar diseases were generally not an issue during 2011. Growers were proactive in their management. Stripe rust although present, was not a major issue, with growers waiting where possible to apply a single fungicide application at GS39. There was concern about yellow leaf spot given the favourable weather conditions; however yield losses were not significant given the drier spring.

Blackleg and sclerotinia were not a major issue across most of the district due to the drier conditions during early spring. The exception was on the eastern side around Holbrook where timely rain at petal fall caused significant losses in some crops due to sclerotinia. Canola diseases could be a problem during 2012 given the 2011 area sown to canola.

Frost events during late September had minimal impact on yields with the exception of a few crops further west. Above-average temperatures coupled with dry conditions experienced during mid September and again from the middle of October impacted on yield potential. Wheat crops experienced leaf tipping due to heat stress following the warm temperatures during September. Widespread rain at the end of September minimised some of the earlier damage.

Rain at harvest again caused issues particularly for later-harvested cereal crops. Canola harvest was excellent as most crops were harvested before the rain hit. Oil levels were high at 40–48% and yields good 1.5–2t/ha (west) to 2–3t/ha (east). Some crops around Holbrook had unexpectedly low yields (1.5t/ha) due to sclerotinia.

Barley yields were slightly lower than expected with the average across the district of 3t/ha. Quality was marketed better than wheat with a third of crops making malt grade however the majority were marketed as feed barley.

Wheat harvest was again affected by wet conditions. Crops harvested before the rain had reasonable quality. Wheat yields were slightly lower than expected at 3–3.5t/ha (west of Corowa). Wheat yields on the eastern side of district were lower than 2010 but generally good. Most crops yielded between 4–4.5t/ha with some averaging 4.5–5t/ha and better crops yielding in excess of 5.5t/ha.

Some varieties held out with better quality than others in the wet conditions. Growers were particularly disappointed with Lincoln, which had poor quality even before the rain. Low falling numbers, shot and sprung grain resulted in mainly feed grade wheat. Other varieties held on better for quality with most growers generally happy with Gregory⊕.

Most early-harvested crops were ASW or GP with some feed and some better APW with very few H1 crops. Protein was at least 1% lower than expected despite nitrogen applications aimed for better protein. Most of the later-harvested crops were feed quality. Low market prices resulted in a lot of grain (particularly feed quality) being stored on farm, to buy time for finding a market later.

Pastures

There was good pasture and weed growth during summer, which kept stock going without reliance on supplementary feeding. Volunteer cereal and canola crops were options as feed sources and lucerne pastures proved to be valuable during this period.

High growth in phalaris-based pastures reduced the establishment of sub-clover due to shading issues. However the subsequent favourable seasonal conditions resulted in excellent clover growth. Some sub-clover pastures performed poorly, possibly due to disease issues such as phytopthera root rot. The mild winter temperatures led to reasonable growth rates during the cooler months.

Competition from annual weedy grasses, such as barley grass and vulpia, was less of a problem than in previous dry seasons. Instead, other broadleaf weeds, such as Paterson's curse and fleabane, emerged as problems.

Although it was a wet harvest for cropping, dry periods during mid spring allowed some opportunity for hay and silage production. However there was still some weather damaged and poorer quality hay produced.

New perennial pastures and lucerne established well under favourable sowing conditions. These pastures struggled in the dry conditions during June but picked up and established well and were grazed earlier than expected due to the excellent conditions.

Good conditions during spring and early summer have led to issues with bulky dry feed during autumn with this having the potential to limit sub-clover establishment during 2012.

Note: The details of this report are based on the NSW DPI Albury agronomy district. The weather data in the report is sourced from Silo weather data.

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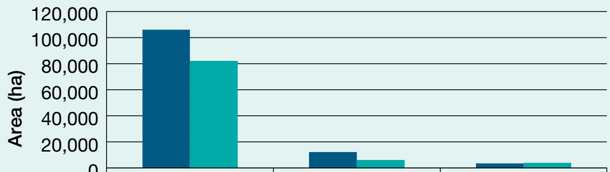
2012 Riverine Plains Membership Survey

On behalf of the Riverine Plains committee and staff thanks to everyone who completed the 2012 membership survey. The survey was sent to 310 grower members during March 2012.

We received a total of 74 responses; a 23% return rate. The member feedback will be a huge help in directing the future research and extension activities of our group.

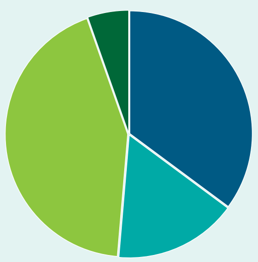
Our members

What area in hectares did your business own, lease or share farm during 2011 and five years ago?

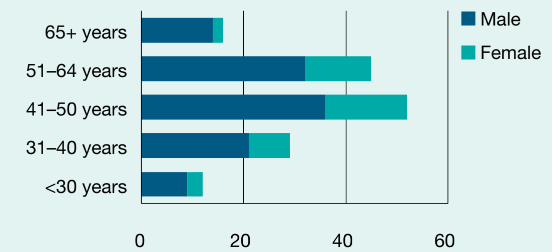


	Owned	Leased	Sharefarmed
2011	105,942	12,207	3,531
2006	82,130	6,048	3,813

Which of the following best describes your farm business?



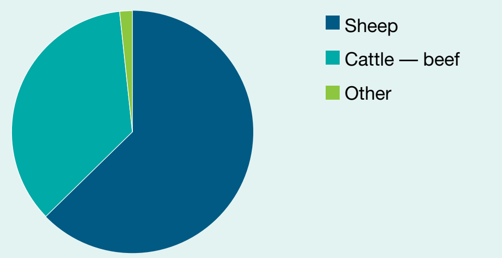
How many people are involved in making management decisions on your farm?



In addition, 32% of respondents employ full-time staff; 68% of respondents employ part-time staff or seasonal labour; and 79% of respondents use contract labour for some part of the farming enterprise.

Livestock

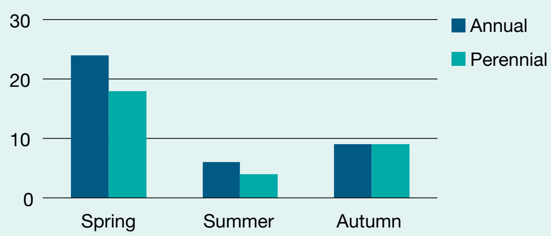
Which livestock did respondents run on their farms during 2011?



Seventy-five per cent of respondents grazed their winter cereal crops, while 96% of respondents grazed their stubble over summer. Twenty-one per cent of respondents grew summer forage crops for grazing livestock.

Eighty-one per cent of respondents had improved pasture as part of their production system. Of these respondents 15% grew only annual pasture, 18% grew only perennial pasture and 67% grew both annual and perennial pastures. The following figure shows at what stage in the season respondents sprayed out their annual and perennial pastures.

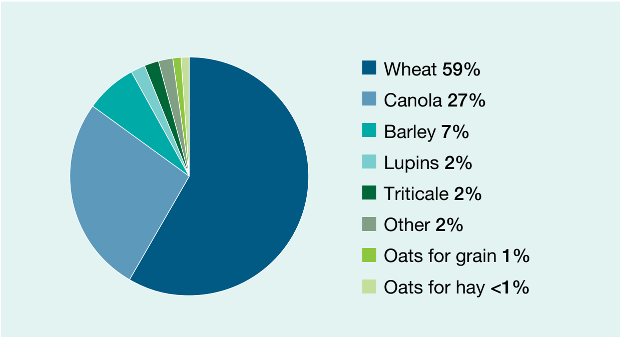
Number of respondents who sprayed out their pasture at different stages during the season.



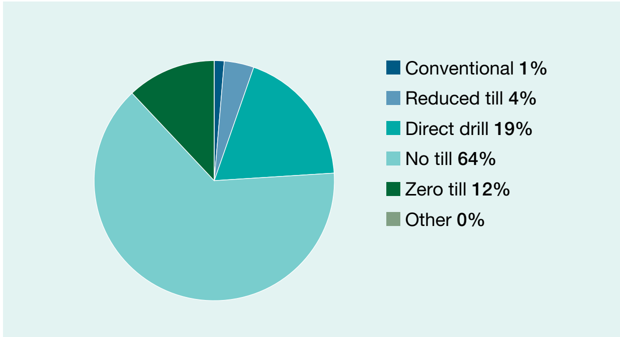


Cropping

Crop area sown.



Breakdown of sowing system used by respondents.

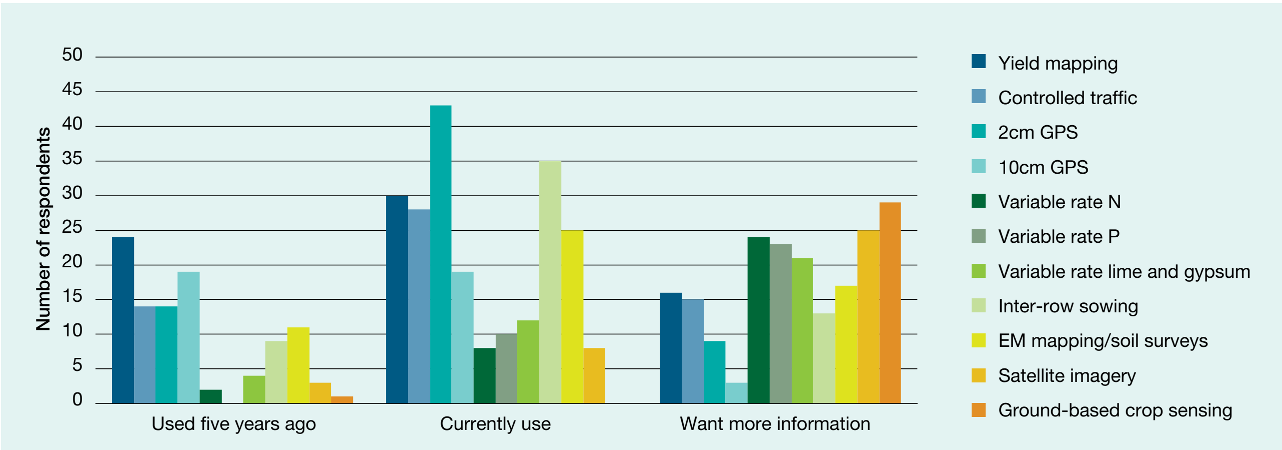


Fifty-seven per cent of respondents used a set rotation in their cropping system.

Compared with five years ago, the percentage of break crop used in cropping rotations has increased for 23% of respondents, decreased for 12% of respondents and stayed the same for the remaining 65% of respondents.

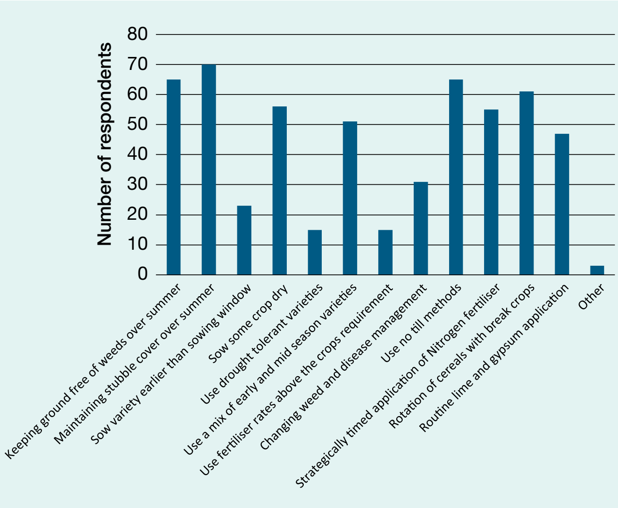
Precision agriculture

The following figure highlights the precision agriculture tools that respondents have used, currently use or would like more information about.



Water use efficiency

Methods respondents have used to increase water use efficiency

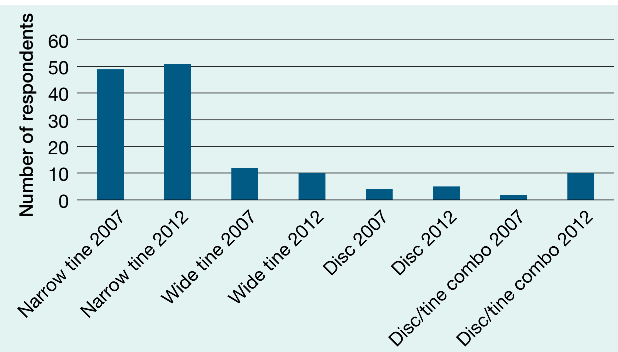


Row spacing

During the past five years 52% of respondents have changed the row spacing of their sowing equipment. Some of the reasons for this change were:

- Stubble handling/stubble retention
- Less ground disturbance
- Went from combine to airseeder
- Contractor changed
- Better trash flow
- Wider machine led to a slight increase in row spacing
- To enable inter-row sowing
- Changed to knife points/press wheels
- Tram track
- Purchased easier-to-move narrow-centre airseeder
- Changed to full stubble retention and no longer needed to be sowing on 8” rows

Sowing equipment used by respondents



Approximately what percentage of your cereal crop nitrogen fertiliser did you apply at different growth stages during 2006 compared with the 2011 season?

This question caused a lot of confusion because 2006 was a drought year (hence no or little in-season nitrogen was applied) and respondents did not know whether or not sowing fertiliser should be included. The results were very inaccurate and unable to be analysed because of this.

Stubble conservation on farm

Of those who responded, 60% said that compared with five years ago the amount of stubble conserved on their farm had increased, 6% said it had decreased and 34% said that it had stayed the same.

Sclerotinia

Sixteen per cent of respondents said they saw sclerotes in their canola seed retained on farm last year. A number of respondents who did not see sclerotes noted that this was because they did not retain canola seed for subsequent crops.

Seventy-one per cent of respondents had seen sclerotinia-affected branches and plants during 2011, while 80% said they were comfortable they would recognise a canola crop affected by sclerotinia.

Seventy-six per cent of those who answered the question believed that sclerotinia may have cost them yield from plants shattering or seeds being smaller and all these respondents believed this yield loss was in the range of 0–0.5 tonnes per hectare.

Yellow leaf spot

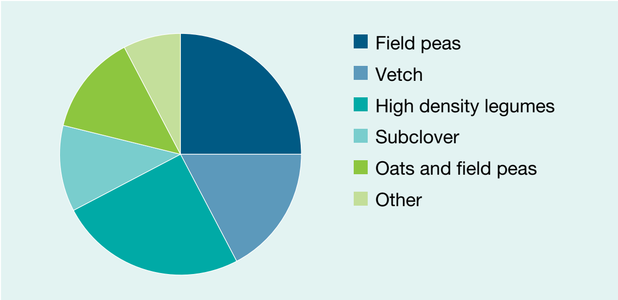
Ninety-six per cent of respondents supported investigative research into yellow leaf spot in southern NSW and north-east Victoria. Ninety-two per cent wanted to know the best fungicides to use to control the disease and the recommended timings of application. Eighty-seven per cent of respondents believed that yellow leaf spot is a wheat disease of serious concern.

Brown manuring strategies

Seventeen per cent of respondents said they would be very confident to put a brown manure crop in the ground, 45% said they would be confident but had a few unknowns, while 38% said they would be not confident at all.

Forty-five per cent of respondents said they would know which crop or pasture they would prefer to use for a brown manure crop, while 55% said they would not know. Of those who knew the crop or pasture they would use,

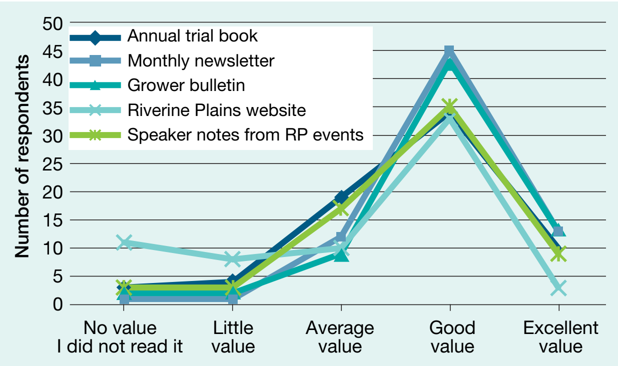
the breakdown of what they would choose to use was as follows:



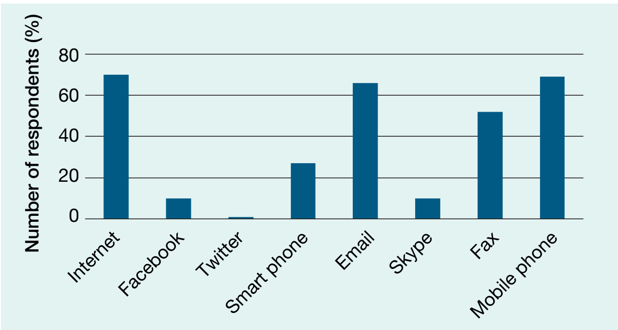
Ninety-seven per cent of respondents believed there was a need for local trials into brown manuring and that these trials should include an economic evaluation of brown manuring.

Extension of information

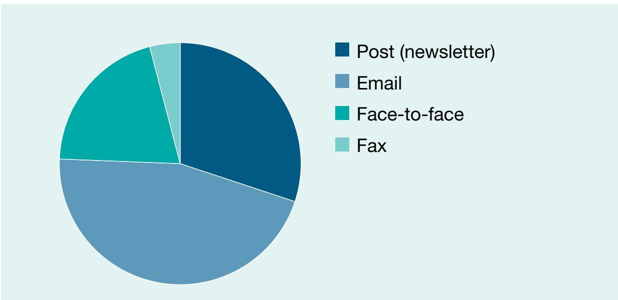
What do you think of our publications?



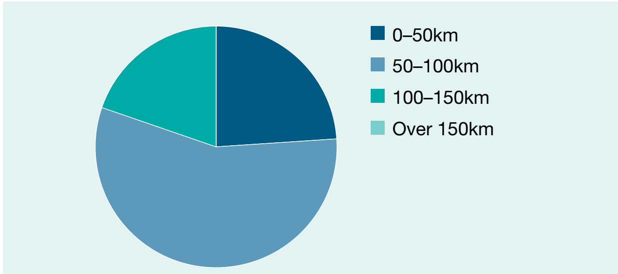
What technology are we using in our farm business?



How would you prefer to receive information from Riverine Plains?



How far do you usually travel to attend a Riverine Plains' event?



Of those members who responded:

- 7% said that distance frequently prevents them from attending Riverine Plains events.
- 49% said distance sometimes prevents them from attending Riverine Plains events.
- 22% said distance infrequently prevents them from attending Riverine Plains events.
- 22% said distance never prevents them from attending Riverine Plains events

Some of the main challenges faced by respondents in their farming systems were:

Cropping	Profitability (cost of production, high input costs, returns) (20), herbicide resistance (8), stubble management (4), managing weeds (5), maintaining yields (4).
Livestock	Labour intensive (8), flies (5), restocking costs (3).
Finances	Reducing debt (10), capital cost to operate and update (4), interest rate uncertainty (3), cashflow (3).
Land management	Soil health (7), weeds (6), biodiversity/ trying to maintain and improve the farm (3), conserving stubble (2).
People management	Skilled labour shortage (13), time (3) communication skills (3), high labour costs (2), retaining staff (2).
Business Management	Time management (9), business management (9), risk management (3), succession planning (3).
Other	Profitability (3), personal wellbeing (3), record keeping (2).

Participants were asked to list the top three topics for which they would like to see further research. The most common responses are shown in the table below.

Priority 1	Growing a profitable pulse crop — year in year out (6), soil carbon (4), weed management (4), soil health (4), brown manuring (3), alternative crops (2), managing herbicide resistance (2), disc seeding technology (2).
Priority 2	Soil health (4), trace elements (3), weed management (3).
Priority 3	Replacements for phosphorus (2), grain marketing (2), ongoing research to improve water use efficiency in crops (2), stubble management (2), new technologies (2), cropping cheaply and for profit — not just yield (2).

Performance of second wheat (wheat on 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]
In conjunction with Riverine Plains Inc
[1] Foundation for Arable Research Australia
[2] Agricultural Research Services

Key points

- Plant establishment at a 22.5cm row spacing was significantly superior to 30cm, which in turn was significantly higher than 37.5cm. The disc drill opener gave better establishment than the tine at the narrow (22.5cm) row spacing but not at the wider row spacing.
- Advantages with the narrow row spacing were seen early in the season in terms of plant population, dry matter (DM) and tiller production. These advantages did not translate to significantly higher yield in this rotation position. This result was identical to the results of the 2010 trial when wheat on wheat yields showed a similar, but not significant, trend for narrow row spacing (22.5cm) to be better than wide row spacing (37.5cm).
- The disc opener produced significantly (0.37t/ha) higher yields than the tine opener, and as a result had a better water use efficiency (WUE).
- Though the narrow row spacing had the highest WUE, the advantages to narrow spacing in second wheat crops have not been as great as those observed in first wheat crops (wheat after canola) where the yield loss associated with wide rows (37.5cm) was 12–13% (2009 and 2010) compared with the narrow row spacing (22.5cm).

Location: Coreen, NSW

Rainfall:
- **Annual:** 599mm
- **GSR:** 187mm (April–Oct)
- **Stored moisture:** 87mm

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

Sowing information:
- **Variety:** Livingston
- **Sowing date:** 3 May 2011
- **Sowing rate:** 85kg/ha
- **Fertiliser:** 85kg/ha MAP + Intake
- **Sowing equipment:** Janke tine with Janke press wheel. Single disc opener.
- **Treatments:** Establishment method x row spacing

Row spacing: 22.5cm, 30cm, 37.5cm

Paddock history:
- **2010** — wheat
- **2009** — canola
- **2008** — triticale (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 spacing in a second-year wheat crop.

Method

A replicated experiment was established to test the effect of a range of drill openers and row spacing on second-year wheat as part of a five-year crop rotation trial. The 2011 trial was the third successive crop superimposed on the original no-till stubble retention trial site.

- 2008 — triticale (farm crop)
- 2009 — canola (first trial year)
- 2010 — wheat
- **2011 — wheat**
- 2012 — canola
- 2013 — wheat

Crop stubble from the 2010 wheat crop was chopped and spread at right angles to the direction of the plots. However due to the high stubble load, plots were raked before sowing to reduce the amount of surface trash.

Results

Crop establishment

The establishment of wheat into wheat stubble from the previous crop resulted in the narrow (22.5cm) row spacing giving significantly better establishment than crops sown at 30cm, which in turn established significantly better than the 37.5cm rows (see Table 1). This result is identical to the results from the second-year wheat established 30m away on the same site during 2010 (see Figure 1).

Across the row spacings the drill opener did not significantly affect establishment. This is in contrast to 2010 when the disc opener was superior (see Figure 2). Stubble loads were much higher for the 2011 season due to the better growing season experienced during 2010. To give an indication of stubble loadings, dry matter (DM) at the 2010 harvest (15t/ha) were almost double that of the 2009 harvest (8t/ha).

There was a significant interaction between row spacing and drill opener. The disc opener at the 22.5cm row spacing established significantly better plant populations than the tine opener, but there was no difference in establishment between disc and tine at the wider row spacings (see Figure 3).

Dry matter production

i) Row spacing

Second-year (wheat on wheat) crops established at the narrow row spacing (22.5cm) produced significantly more DM than crops established at 30cm and 37.5cm up to flowering (GS61), however by harvest there was no significant difference.

Measurements taken early in the season at first node (GS31) and flag leaf emergence (GS39) showed that crops established at 30cm row spacing produced significantly more DM than wheat grown at 37.5cm. There were no significant differences in DM production recorded from flowering to harvest.

TABLE 1 Plant establishment at the three-leaves-unfolded stage (GS13) assessed on 2 June 2011

Row spacing (cm)	Drill opener Plant establishment (plants/m²)		
	Disc	Tine	Mean
22.5cm	176	159	168
30.0cm	137	139	138
37.5cm	112	116	113
Mean	**142**	**138**	**140**
LSD [row spacing]	9		
LSD [drill opener]	7		
LSD [disc[4]] [tine[8]]	15	11	
LSD [disc[4] vs tine[4]]	13		

NOTE: Tine treatments had eight replicates compared with four with the disc treatment)

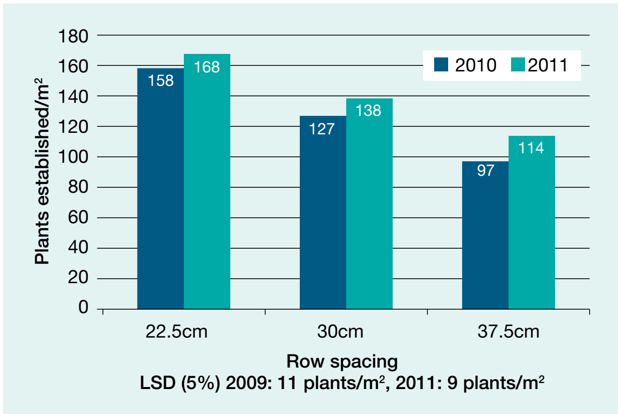


FIGURE 1 Influence of row spacing on plant establishment in second-year wheat crops (after canola) grown during 2010 and 2011 and assessed at the three-leaves-unfolded stage (GS13)*

* Mean of both drill openers

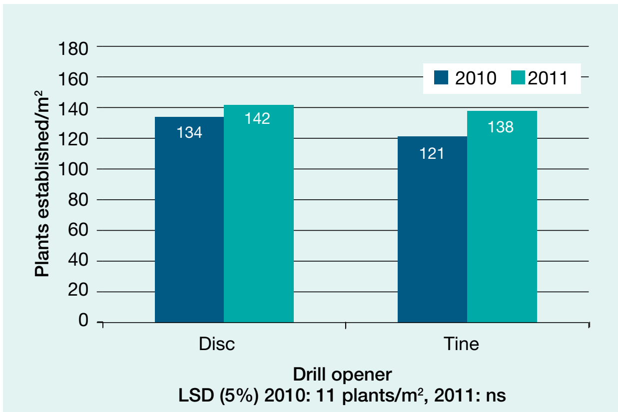


FIGURE 2 Influence of drill opener on plant establishment in second-year wheat crops grown during 2010 and 2011 and assessed at the three-leaves-unfolded stage (GS13)*

* Mean of three row spacings

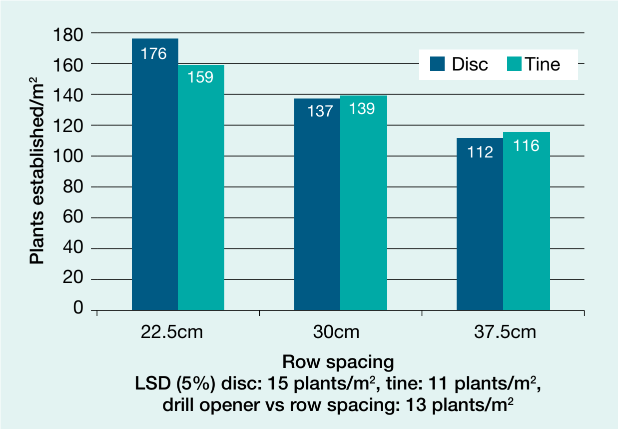


FIGURE 3 Influence of row spacing and drill opener method on plant establishment, measured at the three-leaves-unfolded stage (GS13)

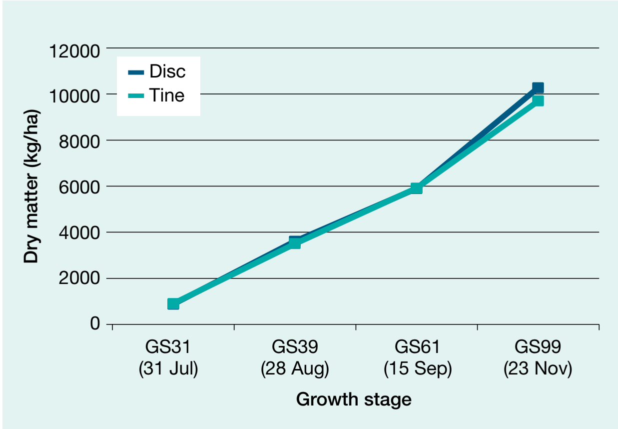


FIGURE 5 Influence of drill opener on dry matter production*
* Mean of three row spacings (31 July – 23 November 2011)

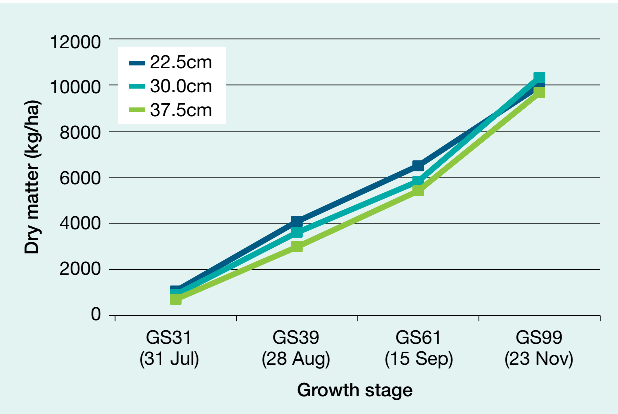


FIGURE 4 Influence of row spacing on dry matter production*
*Mean of both drill openers (31 July – 23 November 2011)

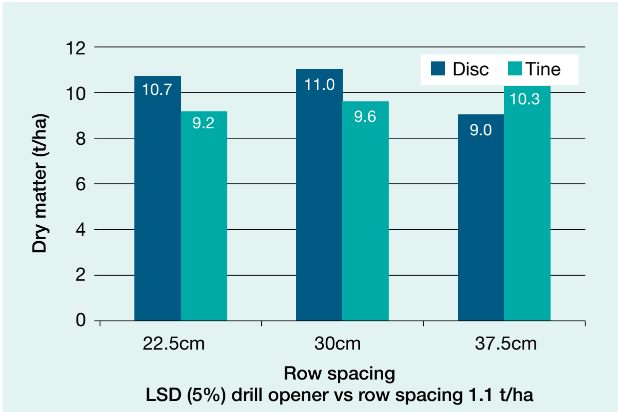


FIGURE 6 Influence of row spacing and drill opener on dry matter production at harvest

ii) Drill opener

Across the three row spacings there were no significant differences generated in DM production throughout the course of the season as a result of drill opener type (see Figure 5).

There was however a significant interaction between row spacing and drill opener on harvest DM (see Figure 6). For reasons that are not clear the tine opener produced inferior harvest DM to the disc at the narrow and middle row spacings but higher DM than the disc at the widest row spacing.

Crop structure

Despite significantly higher plant populations and tillers/m² (tillers assessed at GS31) at the 22.5cm spacing, this did not translate into more DM at harvest, a result that contrasts with previous trials at this site. One feature of the 2011 wheat on wheat trial at Coreen was the high tiller mortality in crops planted in the narrow rows (tillers present at the start of stem elongation that die before harvest without producing a viable head).

Tiller mortality was significantly higher at the narrow row spacing (31%) than at the 30cm (22%) and 37.5cm (16%) spacings, between which there was no difference (see Figure 7). The 22.5cm and 30cm row spacings had significantly more heads/m² than the 37.5cm spacing; however this did not translate into significantly different yields. It is unclear whether partial frost damage at mid flowering contributed to the yield results (see Figure 8).

Yield

i) Yield

The average trial yield was 3.09t/ha, which was 1.8t/ha less than the previous year's wheat on wheat crop grown at the same site.

Despite the early season DM advantage with the narrow row spacing, there were no significant differences in yield generated in the trial. This result is almost identical to

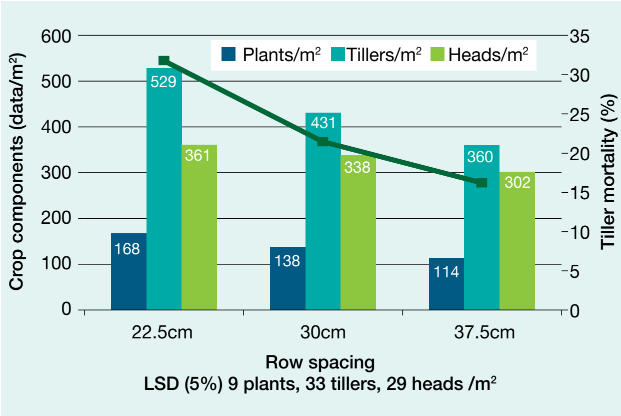


FIGURE 7 Influence of row spacing on crop structure*

* Mean of both drill openers

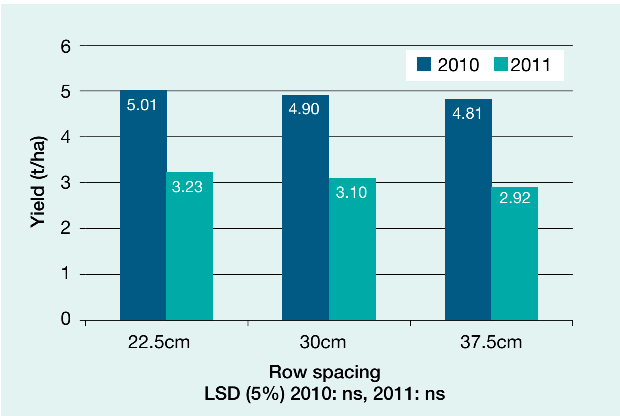


FIGURE 8 Influence of row spacing on second-year wheat (wheat on wheat) yields*

* Mean of both drill openers

the 2010 wheat on wheat trial where there was a trend for narrow row spacing to be higher yielding though the yield differences were not significant (see Figure 8). The lack of yield difference due to row spacing in the second-year wheat (wheat on wheat) rotation position is in contrast to the influence of row spacing on first-year wheat (wheat after canola) at the Coreen site (see Figure 9).

The drill opener had a significant effect on yield in this wheat on wheat trial. When averaged across the three row spacings, the disc opener produced 0.37t/ha more than the tine opener. These results were not seen in the previous wheat on wheat crop (see Figure 10).

Despite a significant interaction between row spacing and drill opener, there was no significant interaction in terms of harvest yields. Figure 11 shows there was a non-significant trend for the disc opener to be higher yielding than the tine opener at all row spacings.

ii) Nitrogen off-take and protein

Differences generated in protein content as a result of opener were small (see Figure 12) but significant (P<0.01). The average protein content of the tine was 13.7% versus 13.1% for the disc, a result likely to have been related to the higher yields obtained with the disc opener. Though not statistically different the highest yielding row spacing (22.5cm) had the lowest level of protein, with very little difference in the protein contents between the 30cm and 37.5cm row spacings. While there was no significant difference in yield or protein due to row spacing, the higher overall protein contents at the wider row spacings tended to be associated with slightly lower yields and visa versa for the narrow row spacing.

There were no significant differences in nitrogen off-take in the grain or straw generated by either the row spacing or the drill opener. All plots received 150kg/ha urea (69kg nitrogen/ha) during early August.

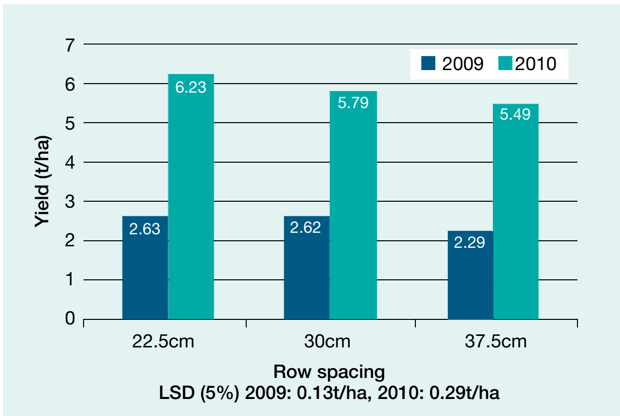


FIGURE 9 Influence of row spacing on yield in first-year wheat during 2009 and 2010*

* Mean of both drill openers

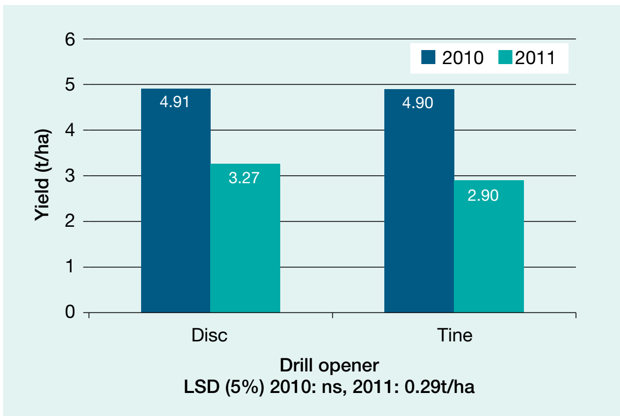


FIGURE 10 Influence of drill opener on wheat on wheat yields*

* Mean of three row spacings

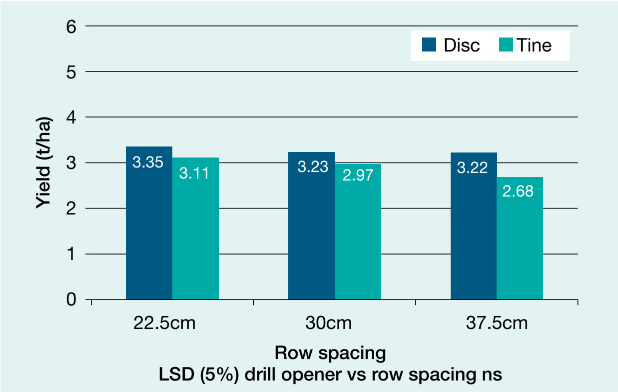


FIGURE 11 Influence of row spacing and drill opener on wheat on wheat yields

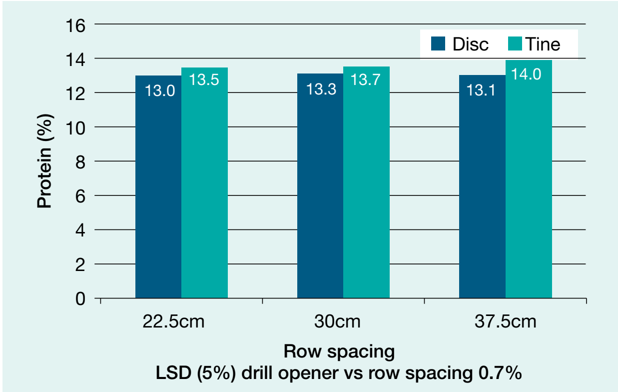


FIGURE 12 Influence of row spacing and drill opener on protein content

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	9950	3230	32.5	11.8	181	93	17.9
30	10324	3101	30.0	11.3	188	86	16.5
37.5	9667	2951	30.5	10.8	176	98	16.8

[1] Based on 187mm of GSR (April–October) + 35% fallow efficiency (87mm) for January–March rainfall (total GSR + stored = 274mm) 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 drill openers

Water use efficiency

At harvest, the narrow (22.5cm) row spacing achieved the highest harvest index at 32.5% and the greatest WUE (11.8kg grain per mm of water available to the crop through the season). However, differences in WUE due to row spacing and drill opener were generally small this season. Despite lower grain yields during 2011 compared with the previous season, there was much better use of the soil water available, when unproductive water (water drained, evaporated or left behind at harvest) was estimated to be in excess of 300mm. This compares with less than 100mm unproductive water during 2011. As a consequence water use efficiency during 2011 was 24% higher than during 2010 (see Table 2).

The disc opener had a higher WUE than the tine opener at 11.9kg/mm and 10.7kg/mm respectively (data not shown).

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 temporarily variable conditions in the Riverine Plains* (RP100007).

Thanks also go to farmer co-operators the Hanrahan 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 spacings at Coreen

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

- Canola following two years of wheat yielded 2.08t/ha despite establishing 50% fewer plants than canola grown during 2009, which yielded 1.59t/ha. The higher yield achieved during 2011 was attributed to more stored soil moisture at sowing.
- The higher biomass produced with the narrower row spacing (22.5cm) did not translate into higher grain yield with the same yield achieved across the narrowest (22.5cm) and widest (37.5cm) row spacings.
- About 102-122kg nitrogen/ha was removed in aboveground biomass (straw and grain). There was no statistical difference in nitrogen off-take between the 22.5cm and 37.5cm row spacings.
- Water use efficiency (WUE) was similar at the 22.5cm and 37.5cm row spacings. There was evidence of slightly higher water loss from the soil in the smaller canopy associated with the wider row spacings, however this was offset by a better harvest index at the 37.5cm row spacing.

Location: Coreen, NSW

Rainfall:
Annual: 599mm
GSR: 187mm (April–Oct)
Stored moisture: 87mm

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

Sowing information:
Variety: 2.1kg/ha Hyola 502 RR (Roundup Ready)
Sowing date: 3 May 2011
Sowing rate: 2.1kg/ha
Fertiliser: 170kg/ha SuPerfect
Sowing equipment: Janke tine with Janke press wheel. Single disc opener.
Treatments: Establishment method x row spacing

Row spacing: 22.5cm, 30cm, 37.5cm

Paddock history:
2010 — wheat
2009 — wheat
2008 — 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.

Trial aim

The aim of this trial was to evaluate the performance of different drill openers at a range of row spacings following two consecutive years of wheat.

Method

A replicated experiment was established to test the effect of a range of drill openers and row spacings on the break of canola after two years of wheat as part of a five-year cropping rotation trial. The 2011 canola crop was the third successive crop superimposed on the original no-till stubble retention trial site.

- 2008 — canola (farm crop)
- 2009 — wheat (first trial year)
- 2010 — wheat (second trial year)
- **2011 — canola**
- 2012 — wheat
- 2013 — wheat

Wheat stubble from the 2010 trial was chopped and spread at right angles to the direction of the plots. However due to the high stubble load resulting from the 2010 season, plots were raked before sowing to reduce the amount of surface trash.

Results

Crop establishment

The narrow (22.5cm) row spacing established significantly more plants/m^2 than the 37.5cm spacing for canola sown into second-year wheat stubbles (see Table 1). There was no statistical difference in establishment between the 30cm row spacing and the widest row spacing (37.5cm). A replicate trial established during 2009 (following two years of cereals on the other side of the track, 30m away on the same soil type) also generated significantly more plants/m^2 in the narrow spacing compared with the 37.5cm row spacing (see Figure 1).

Crop establishment during 2011 was almost half that of 2009 at the same growth stage (two true leaves emerged). This was due to a combination of germination issues, poor seedling vigour and heavy residue loading from the 2010 season.

There was a significant interaction between drill opener and row spacing despite no significant difference in plant establishment as a result of drill opener (P = 0.78) (see Figure 2). For reasons unknown, there was a decrease in establishment for the tine at the 37.5cm spacing. During 2009, when overall establishment was higher, there were significant differences generated as a result of drill opener, with an advantage to the disc opener at establishment (see Figure 3). Establishment this season with the disc opener was less affected by row spacing than the tine.

Dry matter production

i) Row spacing

Canola established with a 30cm row spacing produced significantly more dry matter (248kg/ha) by green bud than

TABLE 1 Plant establishment at the two-true-leaves-emerged stage assessed 38 days after sowing

Row spacing (cm)	Drill opener[1] Plant establishment (plants/m^2)		
	Disc	Tine	Mean
22.5	29	36	32
30.0	28	32	30
37.5	31	20	25
Mean	**29**	**30**	
LSD [row spacing]	5.1		
LSD [drill opener]	4.1		
LSD [disc[4]] [tine[8]]	8.3	5.9	
LSD [disc[4] vs tine[4]]	7.2		

[1] Tine treatments had eight replicates compared with four for the disc treatment.

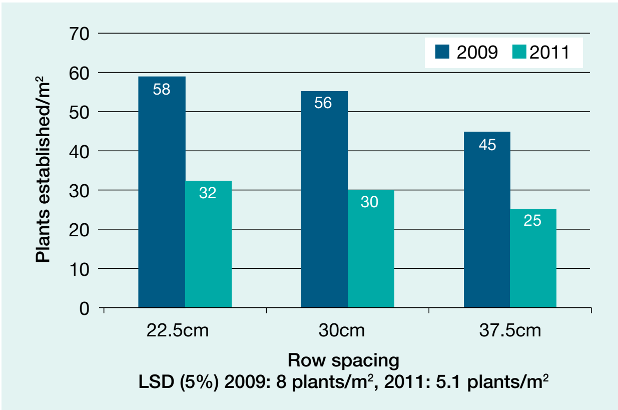

FIGURE 1 Influence of row spacing on canola plant establishment at the two-true-leaves-emerged stage during 2009 and 2011, measured 38 days after sowing*

* Mean of both drill openers

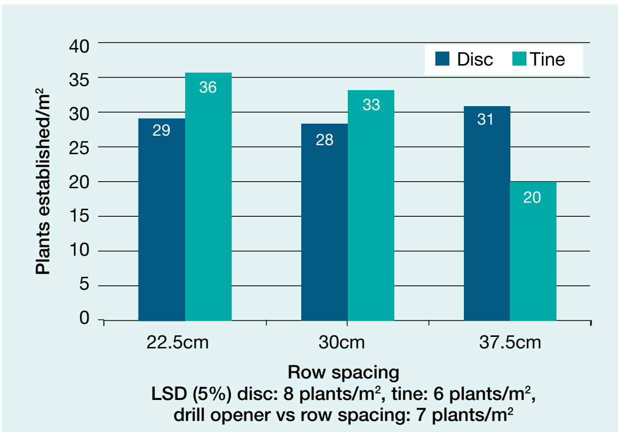

FIGURE 2 Influence of row spacing and drill opener method on canola plant establishment in 2011 measured at the two-true-leaves emerged stage 38 days after sowing

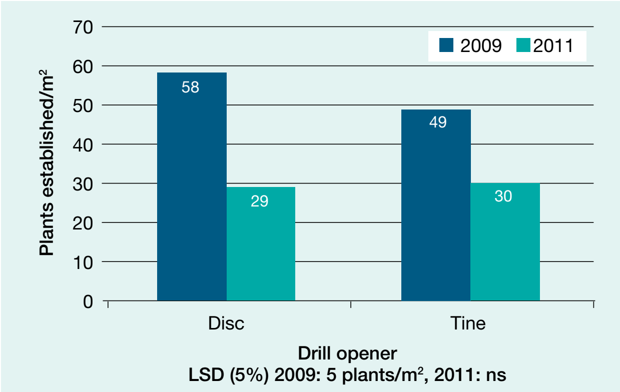

FIGURE 3 Influence of drill opener on canola establishment during 2009 and 2011, measured at the two-true-leaves emerged stage 38 days after sowing*

* Mean of three row spacings

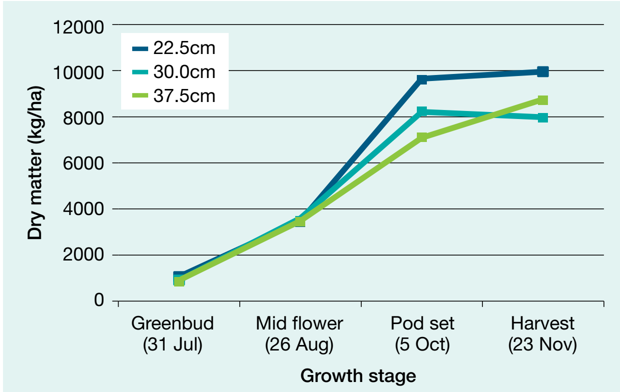

FIGURE 4 Influence of row spacing on dry matter production in canola*

*Mean of both drill openers (31 July – 23 November 2011)

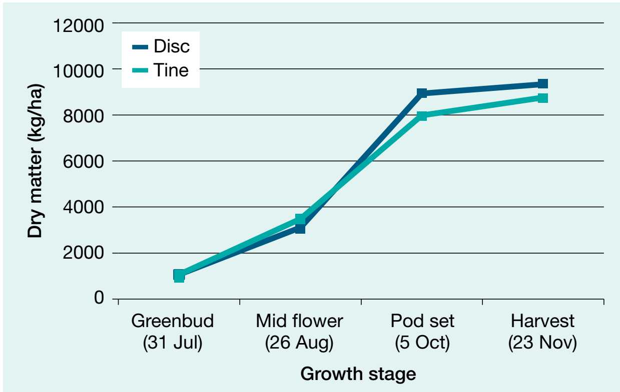

FIGURE 5 Influence of drill opener on dry matter production*

* Mean of three row spacings (31 July – 23 November 2011)

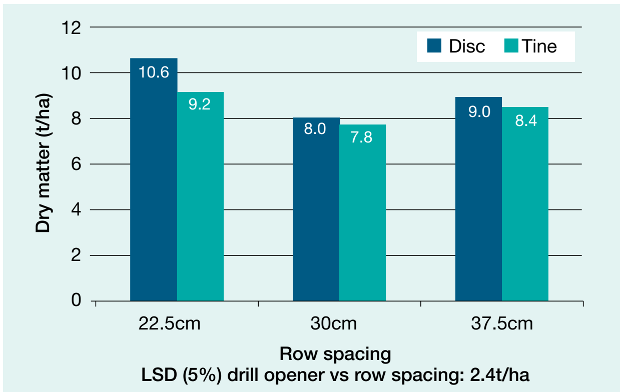

FIGURE 6 Influence of row spacing and drill opener on dry matter production at harvest

canola established at the wider row spacing of 37.5cm, which had produced 802kg DM/ha (see Figure 4). By pod set, the 22.5cm row spacing had produced the greatest amount of DM; significantly more than the 37.5cm row spacing. However, by harvest, total DM production was not significantly different (P = 0.07) between the row spacings, although there was a trend for the narrow row spacing to have the highest amount of DM.

ii) Drill openers

Drill opener did not significantly affect the amount of DM produced by greenbud, pod set or harvest. The disc opener plots, although initially behind in DM production, had produced the most DM by pod set and harvest (see Figure 5).

There were no significant interactions in the DM production between row spacing and drill opener throughout the season to harvest (see Figure 6).

Yield (t/ha)

i) Yield

The trial yielded an average of 2.08t/ha. This was about 0.5t/ha more than that recorded in an identical trial done at the same site during 2009 (cv Hyola 50), despite a much poorer establishment for the 2011 trial (20–36 plants/m^2) than the 2009 trial (45–60 plants/m^2). The main difference between the 2009 and 2011 trials was the amount of soil moisture available at the start of the growing season with nearly 90mm available during 2011 compared with virtually nothing during 2009.

Row spacing significantly influenced final yield (P<0.001) however the influence of row spacing on yield differed between 2009 and 2011 (see Figure 7). During 2009 the 30cm row spacing generated higher yields than the 22.5cm and 37.5cm row spacings. In contrast, there was no significant difference in yield during 2011 between the narrowest (22.5cm) and widest (37.5cm) row spacings. For reasons that are not clearly understood, the intermediate (30cm) row spacing gave significantly inferior yields. There is some evidence to suggest lower dry matter at harvest with the 30cm row spacing but in this trial the difference was not significantly different from the 37.5cm row spacing.

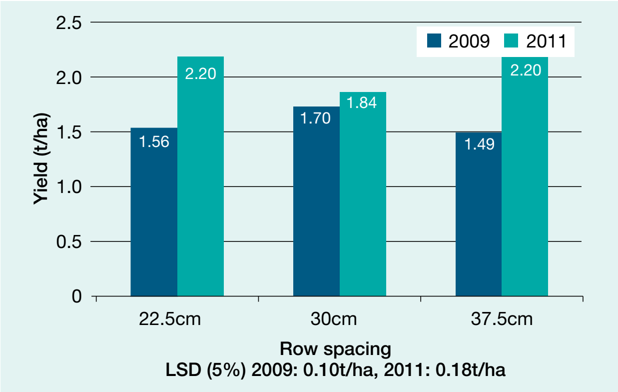

FIGURE 7 Influence of row spacing on yield during 2009 and 2011*

* Mean of both drill openers

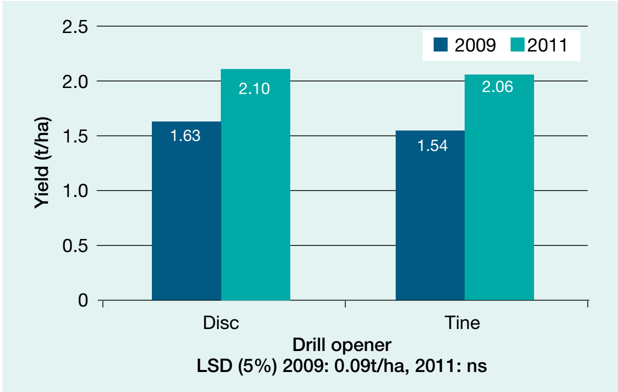

FIGURE 8 Influence of drill opener on yield during 2009 and 2011*

* Mean of three row spacings

The disc opener produced a significant yield advantage over the tine during 2009 but there was no difference between tine and disc opener during 2011 (see Figure 8).

There was no significant interaction between drill opener and row spacing, although there was a trend for the disc treatment to out-yield the tine treatment at each row spacing (see Figure 9).

ii) Oil content (%)

Neither row spacing nor disc opener had a significant impact on oil content.

There was no interaction between drill opener and row spacing. Figure 10 outlines oil content of the individual treatments, which ranged from 42.5–43%.

iii) Nitrogen off-take

Despite the 30cm row spacing having the highest nitrogen content in the harvest components (data not shown). The 30cm spacing had the lowest seed nitrogen removal, which was significantly less than the 22.5cm and 37.5cm row spacings. The 30cm spacing also produced the lowest amount of biomass; this resulted in significantly lower nitrogen off-take (see Figure 11).

Across all row spacings, the disc opener had higher nitrogen off-take than the tine. This difference was significant in the total off-take (P = 0.03) where the disc removed 117kg nitrogen/ha and the tine 109kg nitrogen/ha. All plots received 150kg/ha nitrogen during early August.

Observations and comments

Canola established at the 22.5cm row spacing produced the most above-ground biomass resulting in less evaporation from the soil but more transpiration (water loss) from the canopy itself. The additional biomass at

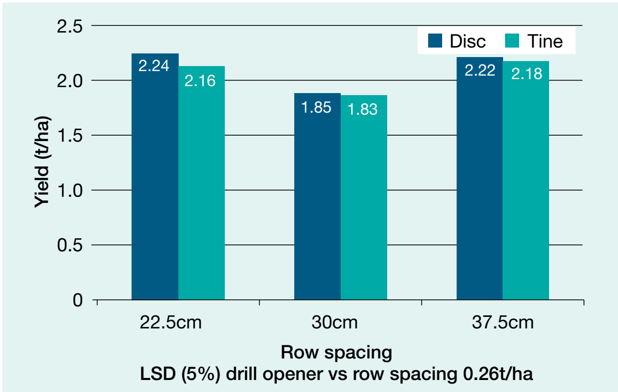

FIGURE 9 Influence of drill opener and row spacing on yield

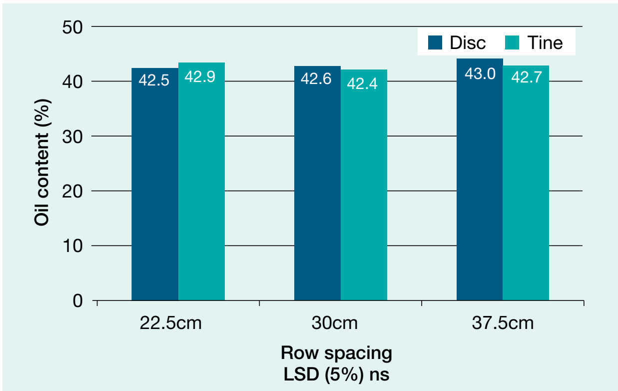

FIGURE 10 Influence of row spacing and disc opener on canola oil content

22.5cm did not however translate to a greater grain yield than that achieved at the 37.5cm spacing. This resulted in the 22.5cm row spacing generating the lowest harvest index and transpiration efficiency despite demonstrating the same overall water use efficiency as the crop established at the 37.5cm row spacing (see Table 2).

The highest transpiration efficiency (kg/ha of grain produced per mm of water) was achieved with the

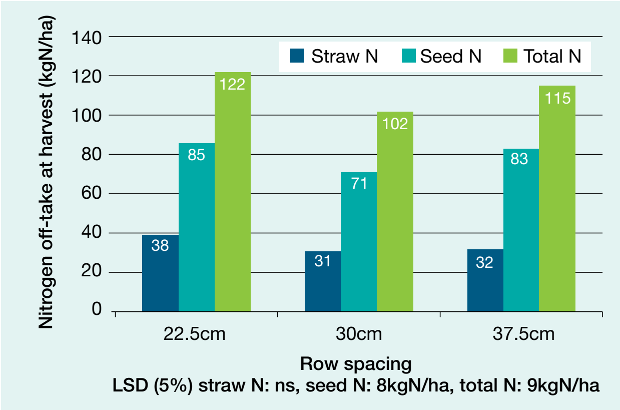

FIGURE 11 Influence of row spacing on nitrogen off-take in the straw and grain*
*Mean of two drill openers

widest row spacing, but resulted in slightly higher levels of unproductive water (water either lost from the soil as evaporation, drainage or water not used by the plant but still present in the soil at harvest).

In the 2009 trial, where canola was established without the benefit of stored soil moisture, the biomass produced at harvest was 40% less than during 2011 but with a 4.4% higher harvest index (on average).

In the 2011 trial the 22.5cm and 37.5cm row spacings resulted in a 16% higher WUE than the 30cm spacing. In the 2009 trial the 30cm row spacing had a 10% higher WUE than the 22.5cm and 37.5cm spacings.

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	9881	2200	22.3	8.0	198	76	11.1
30	7916	1836	23.2	6.7	158	115	11.6
37.5	8727	2200	25.2	8.0	175	99	12.6

[1] Based on 187mm of GSR (April–October) + 35% fallow efficiency of 87mm for the January–March rainfall (total GSR + stored = 274mm) 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

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 temporarily variable conditions in the Riverine Plains* (RP100007).

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

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Performance of 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

- First wheat following the break crop of canola yielded 3.7t/ha with 301mm growing season rainfall (GSR). This was 1.4t/ha less than the first wheat crop following faba beans during 2010, which had a GSR of 537mm.
- Yields of first wheat following canola were significantly higher at the narrow row spacing compared with the 30cm and 37.5cm spacings, between which there was no significant difference. Moving from a 22cm spacing to 30cm and 37.5cm spacings reduced yield by 12% and 14% respectively.
- Establishment at the 22.5cm row spacing was significantly higher than establishment in the 30cm rows, which in turn was significantly superior to the 37.5cm spacing.
- Dry matter (DM) production was significantly higher at the 22.5cm and 30cm row spacings than at the 37.5cm spacing.
- Although the type of drill opener did not significantly effect establishment or DM production, the tine opener was significantly higher yielding than the disc opener (by 0.39t/ha).

Location: Bungeet, VIC

Rainfall:
- **Annual:** 629mm
- **GSR:** 301mm (April–Oct)
- **Stored moisture:** 115mm

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

Sowing information:
- **Variety:** Young
- **Sowing date:** 1 June 2011
- **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:
- **2010** — canola
- **2009** — wheat
- **2008** — triticale (farm cereal)

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 a canola break.

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 canola as part of a five-year cropping rotation trial.



The 2011 trial was the third successive crop superimposed on the original no-till stubble retention trial site.

- 2008 — wheat (farm crop)
- 2009 — wheat (first trial year)
- 2010 — canola (second trial year)
- **2011 — wheat**
- 2012 — cereal

Crop stubble from the 2010 canola crop was chopped and spread at right angles to the direction of plots.

Results

Crop establishment

The narrow (22.5cm) row spacing resulted in significantly more wheat plants establishing into canola stubble than the wheat sown at the 30cm spacing. The 30cm spacing had significantly better establishment than the 37.5cm spacing at both 25 and 42 days after sowing. This was the same as that observed during the first wheat trial following faba beans established in the same paddock the previous season (see Figure 1).

Drill opener did not significantly affect establishment at either of the two assessment times (see Figure 2). The same result was observed during the 2010 first-year wheat crop assessed at the three-leaves-unfolded stage (GS13).

Although there were significant differences in establishment between the row spacings, there was no significant interaction between row spacing and drill opener on plant establishment (see Figure 3).

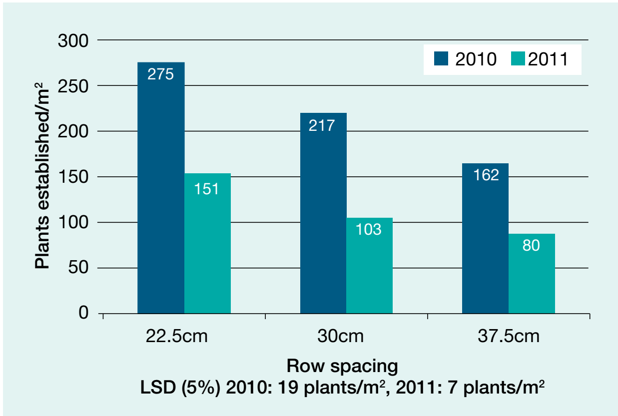

FIGURE 1 Influence of row spacing on plant establishment in first-year wheat crops grown during 2010 and 2011, assessed at the three-leaves-unfolded stage (GS13)*

* Mean of both drill openers

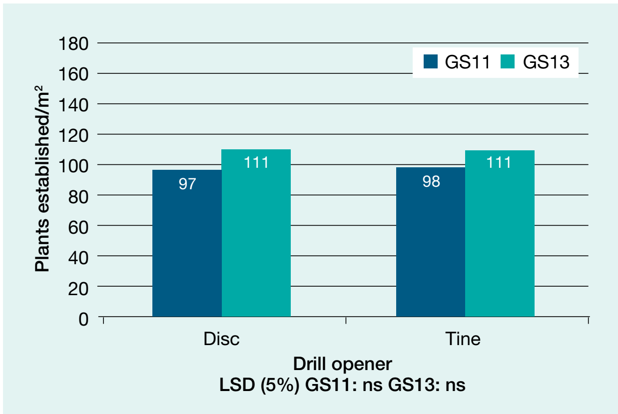

FIGURE 2 Influence of drill opener on plant establishment at the one- and three-leaves-unfolded stages (GS11 and GS13)*

* Mean of three row spacings

TABLE 1 Plant establishment at first-leaf-unfolded stage (GS11) and three-leaves-unfolded stage (GS13) assessed 25 and 42 days after sowing

Row spacing	Drill opener[1] Plant establishment (plants/m^2)					
	26 June 2011			13 July 2011		
	Disc	Tine	Mean	Disc	Tine	Mean
22.5cm	130	135	**133**	151	152	**151**
30.0cm	90	85	**87**	105	101	**103**
37.5cm	71	73	**72**	78	81	**80**
Mean	**97**	**98**		**111**	**111**	
LSD [row spacing]	8			7		
LSD [drill opener]	7			6		
LSD [disc[4]] [tine[8]]	13	12		12	10	
LSD [disc[4] vs tine[4]]	10			8		
Interactions — Drill opener x row spacing				ns		

[1] Tine treatments had eight replicates compared with four for the disc treatment

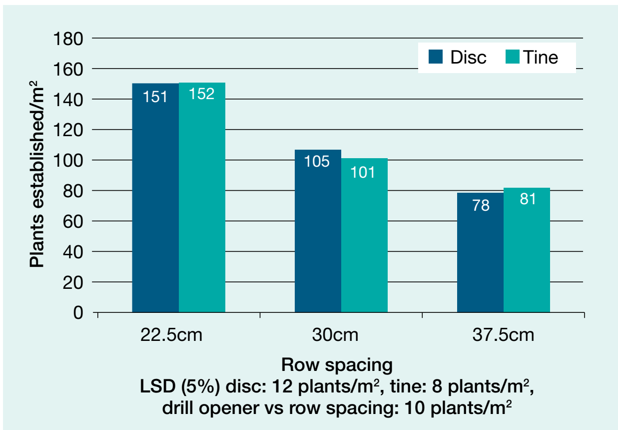

FIGURE 3 Influence of row spacing and drill opener method on plant establishment at the three-leaves-unfolded stage (GS13)

Dry matter production

i) Row spacing

Row spacing caused significant differences in dry matter (DM) production throughout the growing season in first-year wheat established following canola. Assessments done at first node (GS31) and flag leaf emergence (GS39) showed significantly more DM at the 22.5cm row spacing than the 30cm spacing, which in turn had significantly more DM than the widest row spacing of 37.5cm. However, by the start of flowering (GS61) the difference in DM production between the 30cm and 37.5cm row spacings was no longer significant. At harvest, the DM production of the 22.5cm and 30cm spacings was significantly greater than that of the widest row spacing.

ii) Drill opener

There were no significant differences in DM production throughout the course of the season as a result of drill opener (mean of three spacings) (see Figure 5).

However there was a significant interaction between drill opener and row spacing on harvest DM production, which was significantly greater with the tine at the 37.5cm row spacing. While the disc opener produced more DM than the tine at the narrowest spacing, this was not statistically significant (see Figure 6). There were no significant differences in DM production between openers at the 30cm spacing.

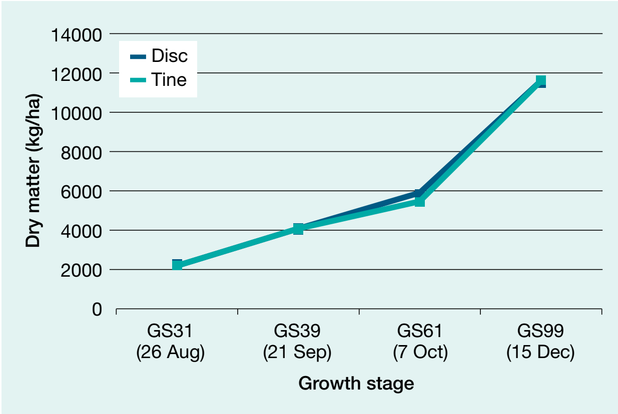

FIGURE 5 Influence of drill opener on dry matter production*
* Mean of three row spacings (26 August – 15 December 2011)

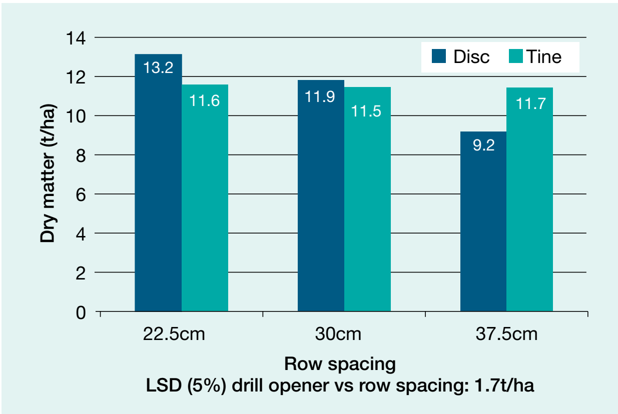

FIGURE 6 Influence of row spacing and drill opener on dry matter production at harvest

Crop structure

The 22.5cm row spacing had significantly more tillers and heads/m² than the 30cm spacing, which in turn had significantly more tillers and heads/m² than the 37.5cm spacing. This correlated with the DM production figures. Crop established at the widest row spacing produced more tillers per plant (3.9 tillers/plant) than the narrowest row spacing (3.4 tillers /plant). The average level of tiller mortality (tillers present at stem elongation that do not produce a viable head) in the trial was 35% and the narrowest row spacing had the highest mortality at 39%. The widest row spacing (37.5cm) produced almost one more head per plant than the narrowest spacing, although absolute head numbers were higher at the narrower row spacing (see Figure 7).

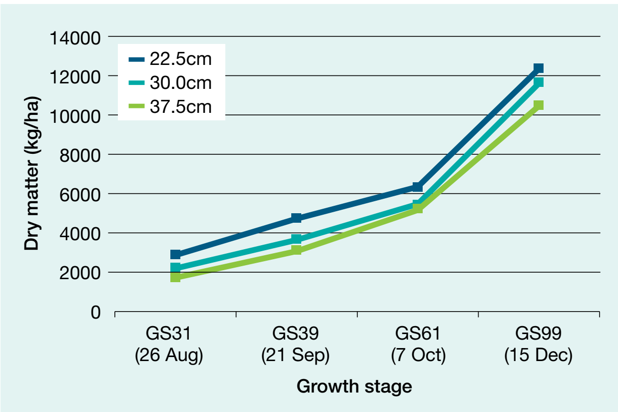

FIGURE 4 Influence of row spacing on dry matter production*
*Mean of both drill openers (26 August – 15 December 2011)

Yield

i) Yield

First wheat following canola yielded on average 3.7t/ha, compared with first wheat after faba beans grown in the same paddock during 2010, which yielded an average of 5.07t/ha. There was an additional 236mm of growing season rainfall (GSR) during 2010 than 2011 and, as a result, stored soil moisture during 2011 was already at 115mm at the start of the growing season.

Both the 2010 and 2011 trial years showed the same significant yield differences at harvest whereby the 22.5cm row spacing was significantly higher yielding

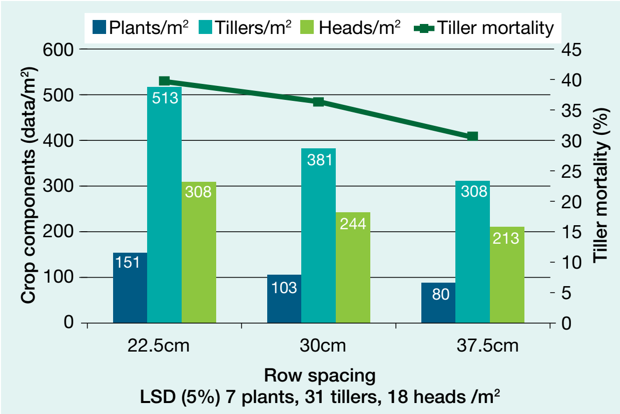

FIGURE 7 Influence of row spacing on crop structure*

* Mean of both drill openers

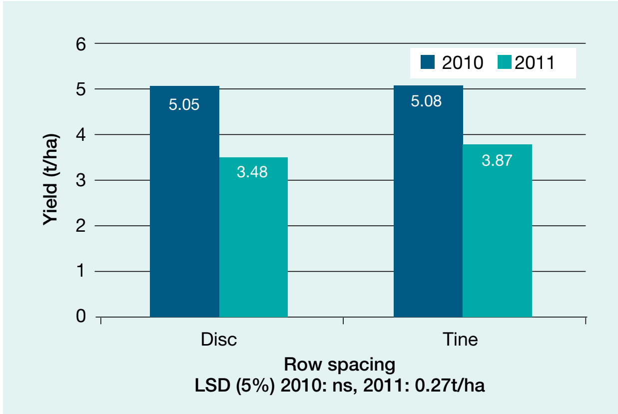

FIGURE 9 Influence of drill opener on first-year wheat yields after the break*

* Mean of three row spacings

than the 30cm and 37.5cm row spacing (between which there was no significant yield difference) (see Figure 8).

In terms of average yield (mean of the three spacings) the tine opener yielded significantly more (0.39t/ha) than the disc opener, despite no differences in initial crop establishment. The 2010 harvest data also showed a small advantage to the tine opener although this was not statistically significant (see Figure 9).

There was no significant interaction between row spacing and drill opener on grain yields in this trial.

Both row spacing and drill opener affected grain yield in this trial. The tine opener was significantly higher yielding than the disc at the narrowest row spacing. While there was a trend for the tine opener to out-yield the disc opener at the 30cm and 37.5cm spacings, this was not statistically significant (see Figure 10).

The yield of the disc opener was significantly higher at the 22.5cm spacing (3.78 t/ha) than at the 37.5cm spacing (3.26 t/ha).

The tine and disc openers at the narrowest row spacing yielded significantly more than the tine and disc openers at the 37.5cm spacing.

ii) Protein content

There were no significant differences generated in protein as a result of row spacing or opener.

iii) Nitrogen off-take

In this first wheat rotation position the total nitrogen off-take of the tine opener (107kg/ha) was significantly more than the disc opener at 98kg/ha. The amount of nitrogen removed in the straw was similar across all treatments.

Narrower row spacings had greater amounts of nitrogen removed in the grain, which was significantly more than that of the two wider row spacings (see Figure 12). The drill opener also had a significant impact, with the tine opener plots removing an additional 5.6kg/ha than the disc opener.

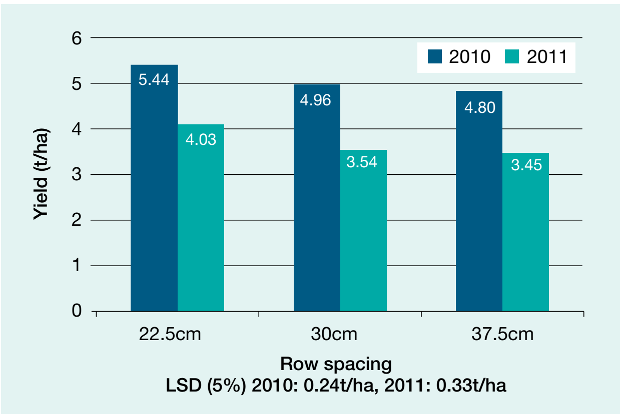

FIGURE 8 Influence of row spacing on first-year wheat yields after faba beans during 2010 and canola during 2011*

* Mean of both drill openers

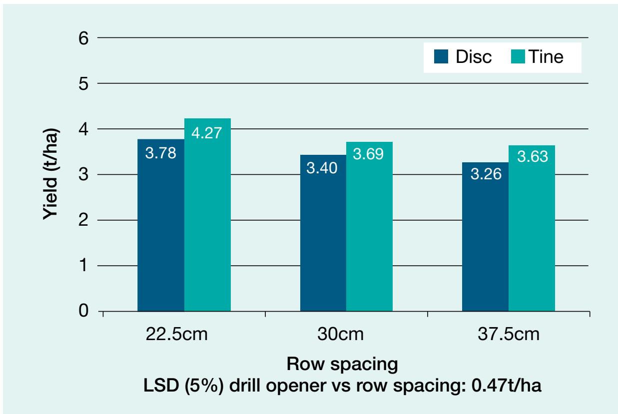

FIGURE 10 Influence of row spacing and drill opener on yield

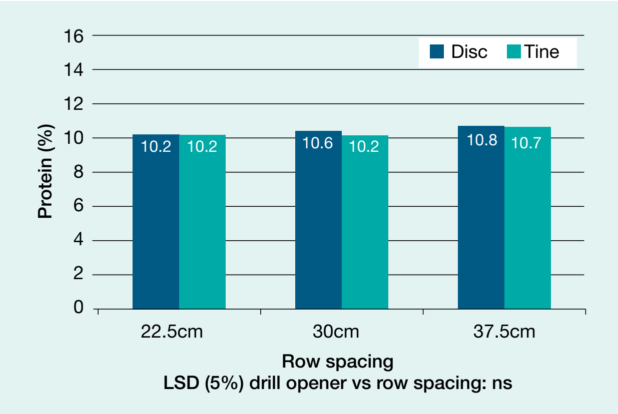

FIGURE 11 Influence of row spacing and drill opener on protein

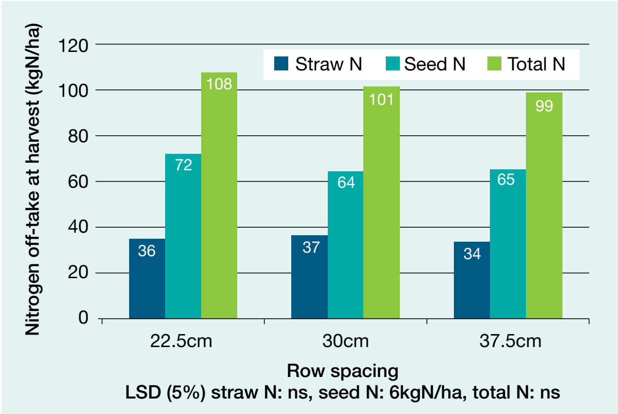

FIGURE 12 Influence of row spacing on nitrogen off-take*

* 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	12378	4026	32.5	9.7	225	191	17.9
30	11680	3545	30.4	8.5	212	203	16.7
37.5	10474	3453	33.0	8.3	190	225	18.1

[1] Based on 301mm of GSR (April–October) + 35% fallow efficiency (115mm) for January–March rainfall (total GSR + stored = 416mm) 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

Water use efficiency

The narrow row spacing produced the highest yields and had the highest WUE at 9.7kg of grain produced for every millimetre of water available to the crop through the season. The amount of water available was calculated as GSR plus stored moisture at sowing (calculated as 35% efficiency of the summer fallow rainfall), which totalled 416mm.

The narrowest row spacing produced the largest biomass at harvest and therefore lost the most water through transpiration from the canopy. It was estimated that for every millimetre of water transpired through the canopy at the 22.5cm row spacing there was 17.9kg/ha of grain produced. The 37.5cm row spacing, which produced the smallest canopy biomass at harvest, had a slightly higher transpiration efficiency of 18.1mm, however more water was estimated to be unproductive at this spacing compared with the 22.5cm row spacing (225mm vs 191mm).

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 temporarily variable conditions in the Riverine Plains* (RP100007).

Thanks also go to farmer co-operators John Alexander and John Seidel as trial manager.

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Performance of second wheat (wheat on wheat) after faba beans 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

- In second wheat after faba beans, moving from a narrow row spacing of 22.5cm to 30cm and 37.5cm row spacings reduced yield by 4% and 10% respectively. This compares with respective yield reductions of 12% and 14% in the first wheat trial grown in the same paddock at the same time.
- The narrow row spacing (22.5cm) produced greater biomass than the wider row spacing but had a relatively poor harvest index (26%) compared with other row spacings in this trial.
- There was no difference in crop establishment or yield due to drill opener (tine versus disc), however plant establishment was superior with the narrow row compared with the wider spacings tested.
- It was estimated that the narrow row spacing resulted in better water use efficiency than the wider spacings, despite having a lower harvest index.

Location: Bungeet, Vic

Rainfall:
Annual: 629mm
GSR: 301mm (April–Oct)
Stored moisture: Estimated 115mm (estimated at 35% fallow efficiency)

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

Sowing information:
Variety: Young
Sowing date: 1 June 2011
Sowing rate: 85kg/ha
Fertiliser: 115kg/ha (85+30 with resowing) 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:
2010 — wheat
2009 — faba beans (farm crop),
2008 — wheat (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 second wheat crop after the break crop (faba beans).

Method

A replicated experiment was established to test the effect of a range of drill openers and row spacings on the second wheat crop after the break of faba beans as part of a four-year cropping rotation trial. The 2011 trial was the second successive crop superimposed on the original no-till stubble retention trial site.

- 2008 — wheat (farm crop)
- 2009 — faba beans (farm crop)
- 2010 — wheat
- **2011 — wheat**
- 2112 — canola
- 2013 — wheat

TABLE 1 Plant establishment at the one-leaf-unfolded stage (GS11) and three-leaves-unfolded stage (GS13) assessed 25 and 42 days after sowing

Row spacing (cm)	Drill opener[1] Plant establishment (plants/m²)					
	26 June 2011			13 July 2011		
	Disc	Tine	Mean	Disc	Tine	Mean
22.5	129	128	**128**	155	148	**152**
30.0	94	91	**92**	114	105	**109**
37.5	73	73	**73**	81	91	**86**
Mean	**99**	**97**		**116**	**114**	
LSD [row spacing]	9			8		
LSD [drill opener]	8			7		
LSD [disc[4]] [tine[8]]	15	13		13	11	
LSD [disc[4] vs tine[4]]	11			9		
Interactions — drill opener x row spacing (13 July)				*		

[1] Tine treatments had eight replicates compared with four with the disc treatments.

Crop stubble from the 2010 wheat crop was chopped and spread at right angles to the direction of the plots. However due to the high stubble load, plots were raked before sowing to reduce the amount of surface trash

Results

Crop establishment

The establishment of this second-year wheat into the stubble of the previous 5t/ha wheat crop resulted in the narrow (22.5cm) row spacing establishing significantly more plants/m² than crops sown at 30cm. The 30cm spacing in turn established significantly more plants/m² than the 37.5cm spacing at 25 and 42 days after sowing. Establishment results from this second-year wheat trial were very similar to those of the replicated first wheat trial sown in the same paddock at the same time (see Figure 1).

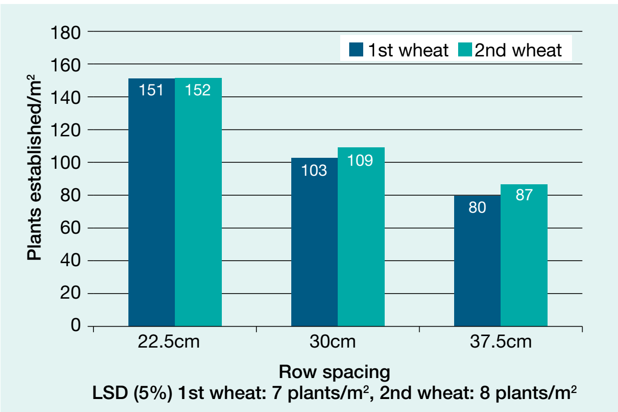

FIGURE 1 Influence of row spacing on plant establishment at the three-leaves-unfolded stage (GS13) in first and second-year wheat established on the same site*
* Mean of both drill openers

The drill opener did not have an impact on crop establishment in either the first or second wheat rotation positions (see Figure 2).

There was a significant ($P<0.05$) interaction between row spacing and drill opener on 13 July assessment. This was because the narrow row spacing had a higher plant population with the disc seeder, while at the widest row spacing, the tined seeder provided better establishment (see Figure 3). Crop establishment with the disc at the 22.5cm and 30cm row spacings was better than the tine opener, although not significantly.

Dry matter production

i) Row spacing

Dry matter (DM) production was significantly higher at the 22.5cm spacing than it was at the 30cm spacing, which in turn was significantly higher than the 37.5cm spacing until flag leaf emergence (GS39). At the

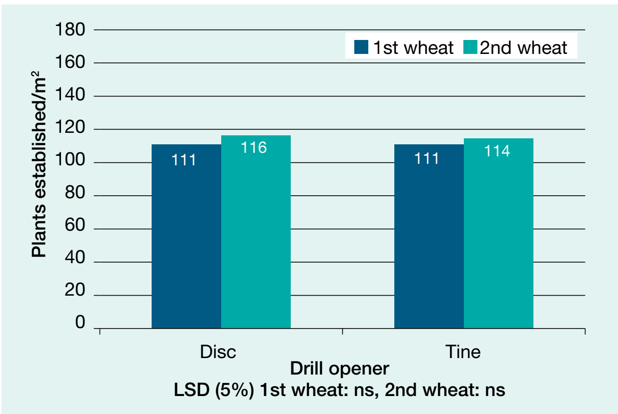

FIGURE 2 Influence of drill opener on plant establishment at the three-leaves-unfolded stage (GS13) in first and second-year wheat established on the same site
* Mean of three row spacings

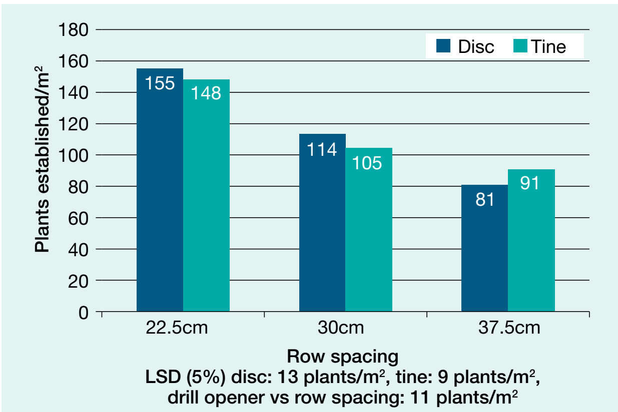

FIGURE 3 Influence of row spacing and drill opener method on plant establishment, at the three-leaves-unfolded stage (GS13)
* Mean of both drill openers

start of flowering (GS61) the narrow row spacing had significantly more DM than the widest row spacing, with the 30cm spacing falling non-significantly between the two. At harvest the difference in DM production between the 30cm and 37.5cm spacing had increased and was again statistically significant (LSD 1175kg DM/ha) (see Figure 4).

ii) Drill opener

There were no significant differences generated in DM production throughout the course of the season as a result of drill opener (see Figure 5).

There was however a significant interaction between row spacing and drill opener on DM production at harvest whereby the tine opener produced significantly more DM than the disc at the widest row spacing but not at the narrower spacing (see Figure 6). This trend is similar to that observed in the neighbouring first wheat trial.

Crop structure

With the exception of the large quantity of DM produced at harvest by the narrow row spacing in this second-year wheat trial, canopy composition was similar to that observed in the first wheat trial. At the 22.5cm row spacing there were significantly more tillers/m^2 and heads/m^2 than in the 30cm row crop, which in turn had significantly more tillers/m^2 and heads/m^2 than the 37.5cm row spacing (see Figure 7).

Yield

i) Yield

Second-year wheat (wheat on wheat after faba beans) on average produced 0.18t/ha more than the first wheat, the two trials having been established with 64kg and 55kg of deep mineral nitrogen/ha respectively; both trials received 130kg urea/ha during late August.

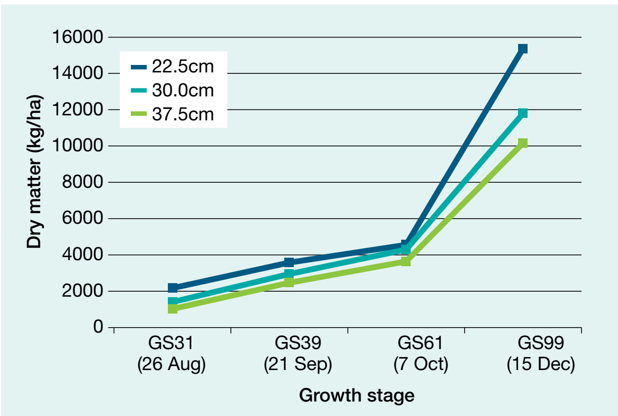

FIGURE 4 Influence of row spacing on dry matter production*
*Mean of both drill openers (26 August – 15 December 2011)

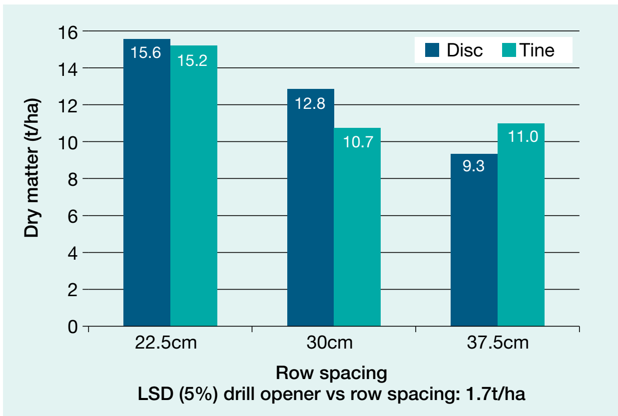

FIGURE 6 Influence of row spacing and drill opener on dry matter production at harvest*
* Mean of both drill openers

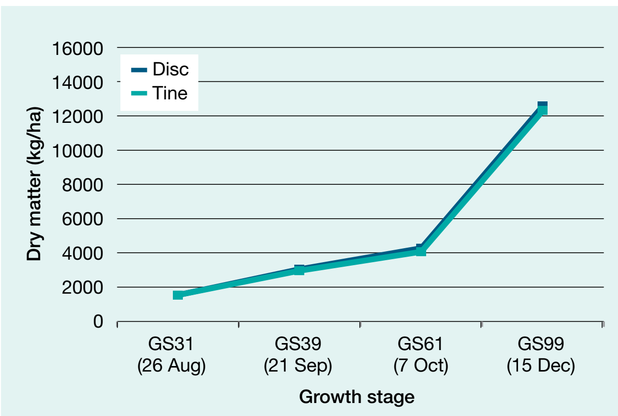

FIGURE 5 Influence of drill opener on dry matter production*
* Mean of three row spacings (26 August – 15 December 2011)

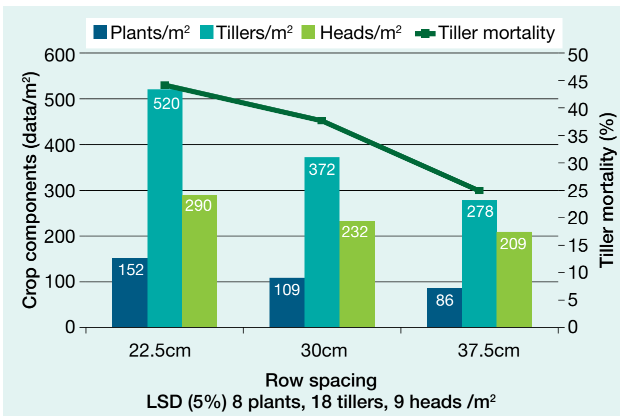

FIGURE 7 Influence of row spacing on crop structure*
* Mean of both drill openers

The narrow row spacing yielded significantly more than that of the widest row spacing (see Figure 8). The 30cm row spacing yield was intermediate and not significantly different to either the narrow or widest row spacings. The reduction in yield as row spacing increased from 22.5cm to 37.5cm was about 10%. This compares to a 14% reduction in yield in the first wheat trial sown at the same time in the same paddock.

There was no difference generated in the trial as a result of drill opener used (see Figure 9). This lack of yield difference due to drill opener type was seen in equivalent second-year wheat trials grown at both the Bungeet and Coreen trial sites.

There was no significant interaction between row spacing and drill opener on the yields obtained in the trial (see Figure 10). There was a non-significant trend for the disc opener to outyield the tine opener at the two narrower row spacings, however at the widest spacing the tine opener was better.

ii) Protein content

There were no significant differences generated in the protein content of the crop as a result of opener or row spacing (see Figure 11). The mean protein content of the second-year wheat crop was 10.2%, which was 0.2% behind that of the first-year wheat crop.

iii) Nitrogen off-take

Total nitrogen off-take was greatest at the narrowest row spacing. The widest row spacing had significantly less nitrogen removed in the grain and total nitrogen off-take than that of the two narrower row spacings. There was no significant difference in the amount of nitrogen removed in the straw. Drill opener had no effect on the nitrogen off-take of the crop.

Observations and comments

It was estimated that the narrowest row spacing produced the best overall WUE (see Table 2) at 9.7kg grain for every millimetre of water available to the crop through the season (growing season rainfall plus 35% efficiency of summer fallow rainfall totalling 416mm). However, the narrow row

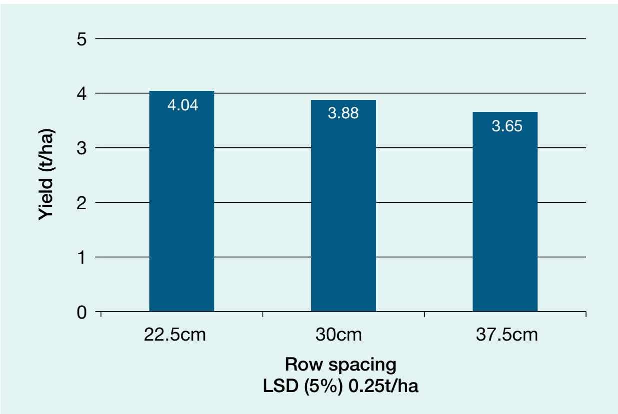

FIGURE 8 Influence of row spacing on yield*
* Mean of both drill openers

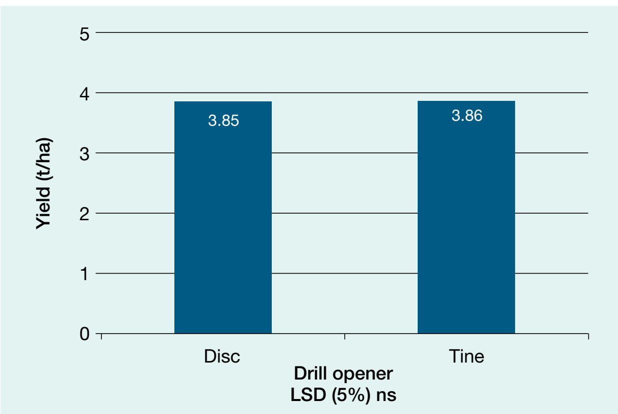

FIGURE 9 Influence of drill opener on yield*
* Mean of three row spacings

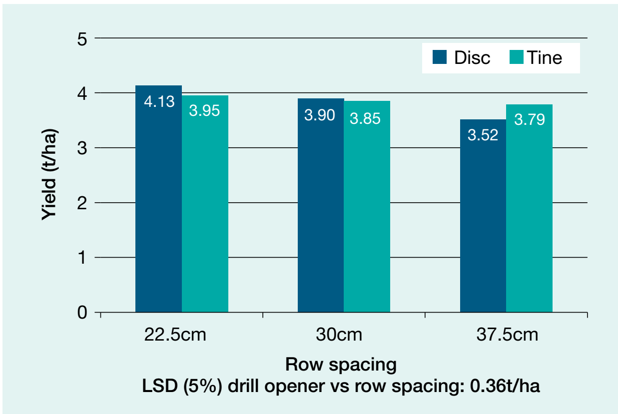

FIGURE 10 Influence of row spacing and drill opener on yield*
* Mean of both drill openers

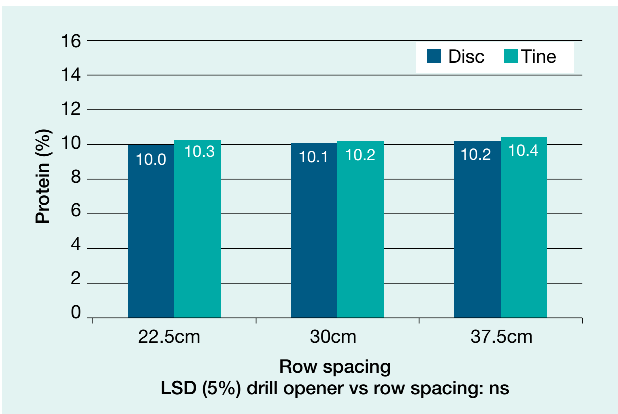

FIGURE 11 Influence of opener and row spacing on protein



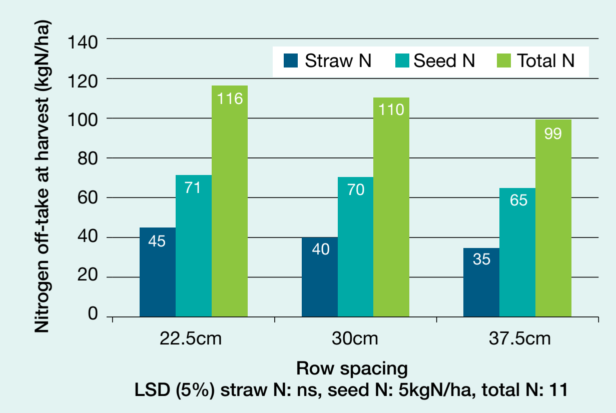

FIGURE 12 Influence of row spacing on nitrogen off-take*
* Mean of both drill openers

spacing produced a lower harvest index (26.3%) than the first wheat trial at the same site (32.5%).

The lower biomass and high harvest index of the wide row spacing meant it had considerably better transpiration efficiency (efficiency of water that passes through the plant being converted to grain) at 19.8kg of grain for every millimetre of water transpired through the crop compared with 14.5kg/mm in the narrow spacing. However it was also estimated that wider row spacing had about 100mm more unproductive water than the narrowest row spacing. This means it either evaporated, was lost through drainage or was still in the soil at harvest but never used. As a consequence, the overall WUE was poorer with the widest row spacing.

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	15376	4040	26.3	9.7	280	136	14.5
30	11795	3878	32.9	9.3	214	201	18.1
37.5	10160	3653	36.0	8.8	185	231	19.8

[1] Based on 301mm of GSR (April–October) + 35% fallow efficiency (115mm) for January–March rainfall (total GSR + stored = 416mm) 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 drill 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 temporarily variable conditions in the Riverine Plains* (RP100007).

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

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Precision agriculture demonstrations on sowing and fertiliser rates at *Bogandillan*, Rand

John Sykes
John Sykes Rural Consulting

Key points

- Reducing sowing rates to 50kg/ha did not impact on yield, which is consistent with 2009 trial results.
- Yield at the site did not respond to applied phosphorus or nitrogen fertiliser even following early plant growth responses.

Location: *Bogandillan,* Rand, NSW

Rainfall:
Annual: 667mm (avg 490mm)
GSR: 194mm (avg 290mm)

Soil:
Type: Grey clay to red chromosol
pH (H_2O): 5.9
pH ($CaCl_2$): 5.4

Sowing information:
Variety: Lincoln, wheat
Sowing date: 12 May 2011
Sowing rate: 35, 50 and 70kg/ha
Fertiliser: Phosphorus (0, 30, 50, 75 and 100kg/ha as MAP)
Nitrogen (50kg/ha plus 40kg/ha as nitrogen-rich strips)
Herbicides: Glyphosate and trifluralin applied to all plots.
Sowing equipment: Janke 14.6m tine airseeder (300mm rows) equipped with Janke press wheels. Goldacre 29.2m boomspray. Lely spreader with actuator spreading on 29.2m centres. AutoFarm 2cm guidance in the sowing, spraying and spreading.

Row spacing: 30cm

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

Plot size: 800m x 29.2m

Replicates: nil

Aims

- To compare the effects of variable phosphorus and sowing rates on the wheat yield.
- To assess if remote sensing, using Crop Circle normalised difference vegetation index (NDVI), could determine yield differences between the treatments.
- To assess if nitrogen-rich strips and NDVI could be used to better assess in-crop nitrogen requirements.

Background

During 2010 a demonstration was established on *Bogandillan* to examine the effect of variable sowing and phosphorus rates on the yield of wheat grown in high-phosphorus situations.

The site was used as a major demonstration site for precision agriculture (PA) with more than 70 growers attending the main field day. The demonstration was repeated during 2011 to further demonstrate the benefits of PA and to assess the effect of varying phosphorus and sowing rates and nitrogen-rich strips on wheat yield.

Nitrogen-rich strips were used to assess the nitrogen requirements of the crop by highlighting any yield differences. Plots were assessed using a Crop Circle biomass sensor to determine NDVI and highlight any nitrogen differences (see Table 1).

TABLE 1 NDVI results, Rand July 2011

Treatment	NDVI*
Sowing rate 35kg/ha, MAP 50kg/ha	0.3
Sowing rate 35kg/ha, MAP 50kg/ha, plus 40kg/ha of nitrogen as a nitrogen-rich strip	0.4
Sowing rate 70kg/ha, MAP 50kg/ha	0.7
Sowing rate 70kg/ha MAP 50kg/ha, plus 40kg/ha of nitrogen as a nitrogen-rich strip	0.7+

* NDVI calculated as an average of 10 individual measurements taken from each plot from the nitrogen-rich strip and the treatment area to the south of the nitrogen-rich strip.



TABLE 2 Grain yields and results of the visual assessments

Seed and fertiliser treatment	Phosphorus rate (kg/ha)	Plants (plants/m^2)	Tillers (tiller/m^2)	Grains/head	Yield (t/ha)
Sowing rate 70kg/ha, MAP 50kg/ha	11	124	447	38	3.1
Sowing rate 35kg/ha, MAP 50 kg/ha	11	65	321	56	3.2
Sowing rate 50kg/ha, MAP 50kg/ha	11	74	422	44	3.1
Sowing rate 70kg/ha, no fertiliser	0	117	265	66	2.9
Sowing rate 70kg/ha, MAP 30kg/ha	6.5	131	463	42	2.9
Sowing rate 70kg/ha, MAP 50kg/ha	11	128	455	40	2.9
Sowing rate 70kg/ha, MAP 75kg/ha	17.5	119	466	36	2.9
Sowing rate 70kg/ha, MAP 100kg/ha	22	133	421	42	2.9

TABLE 3 Grain quality results

Treatment	Moisture (%)	Protein (%)	C/W (kg/hL)	Screening (%, 2mm)
Sowing rate 70kg/ha, MAP 50kg/ha	9.1	10.4	80	1.2
Sowing rate 35kg/ha, MAP 50kg/ha	8.9	11.2	80	1.5
Sowing rate 50kg/ha, MAP 50kg/ha	9.0	11.1	81	1.5
Sowing rate 70kg/ha, no fertiliser	8.9	10.9	80	2.9
Sowing rate 70kg/ha, MAP 30kg/ha	8.9	11.1	80	3.0
Sowing rate 70kg/ha, MAP 50kg/ha	9.0	11.1	80	2.6
Sowing rate 70kg/ha, MAP 75kg/ha	9.0	11.1	80	2.8
Sowing rate 70kg/ha, MAP100kg/ha	9.0	11.4	81	2.6

Method

Yield maps from 2010 were used to develop two management zones for 2011.

Sowing rates were varied across each zone — 35, 50 and 70 kg/ha.

Phosphorus was applied at rates of 0, 30, 50, 70 and 100kg/ha as MAP.

An 80m nitrogen-rich test strip of 40kg/ha was applied across both zones at GS15. Deep soil nitrogen results and yield targets, assessed using weather predictions and the French and Schultz model, were used to determine a single rate of nitrogen (50kg/ha) for all plots, across both zones, applied at GS31.

Results

While there was a visual response to phosphorus, applied at sowing through to after GS31, this did not translate into yield differences at harvest. There was an initial response to varying sowing rate, but this was not obvious at GS31 and did not translate into a yield response (see Table 2). The results may have been a reflection of the dry spring and the time of application. The addition of phosphorus increased input costs and reduced profits.

There was no visual response from applying nitrogen in the nitrogen-rich strip in either zone. The harvest results showed no yield response in the nitrogen-rich strip, but as these were only 80-metres wide and had additional nitrogen at GS31, the result may not be indicative of whether there was a response at the site.

Overall the yield was disappointing and well below the target. Grain quality was also below target (see Table 3).

SPONSORS

This project is supported by Precision Agriculture Australia's *Training and Demonstration of PA in Practice* (GRDC-funded project SPA00010).

Farmer co-operators: Roy and Leanne Hamilton.

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Precision agriculture demonstrations on variable rate applications of nitrogen fertiliser at *Green Park*, Rand

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John Sykes Rural Consulting

Key points

- Precision agriculture can be used to apply variable rates of nitrogen fertiliser; generating fertiliser savings and optimising yields throughout the paddock.
- Optimising applied nitrogen fertiliser results in optimum yields and gross margin.

Location: *Green Park*, Rand, NSW

Rainfall:
Annual: 672mm (avg 520mm)
GSR: 226mm (avg 320mm)

Soil:
Type: Red Kurosol, Red Chromosol
pH (H_2O): 6.2
pH ($CaCl_2$): 5.5

Sowing information:
Variety: Lincoln, wheat
Sowing date: 18 May 2011
Sowing rate: 65kg/ha
Fertiliser: 60kg/ha MAP
Herbicides at sowing: Glyphosate and Boxer Gold
Sowing equipment: DBS parallelogram seeder, 12.3m with press wheels, Goldacres sprayer, Matador spreader spreading 36m and AutoFarm and Trimble guidance equipment.
Treatments:
- A nitrogen-rich strip of 80kg/ha of nitrogen (160kg/ha urea) was applied during late June across the site.
- Rates of urea from 0–160kg/ha (0–80kg/ha of nitrogen) were applied during mid-August just before GS31.

Row spacing: 31cm

Paddock history:
2010 — canola

Plot size: 640m x 24.6m

Replicates: nil

Aims

- To assess the effect of using variable nitrogen rates on crop yields.
- To determine if nitrogen-rich strips can be used to better determine the need for in-crop nitrogen.

Method

A demonstration trial was established at Rand, NSW to assess the usefulness of precision agriculture (PA) methods for determining in-crop nitrogen requirement. An EM survey was completed during 2009 to identify three management zones for the 2011 crop.

An EM survey was completed during 2009. A soil analysis (0-10cm) was done within each zone during 2009 and used to determine the location of the demonstration. The plan was to determine the optimum rate of urea for each zone within the paddock and to determine if nitrogen-rich strips could be used to assess the variable nitrogen needs of the paddock.

Nitrogen was applied at rates of 0–80kg/ha across all zones during mid August (just before GS31). A nitrogen rich strip of 80kg/ha of nitrogen was applied across the zones during late June.

Zonal deep soil nitrogen soil tests (0–60cm) were completed during July 2011. The results indicated that phosphorus in all zones was high and that deep soil nitrogen was moderate to high in all plots. During 2012 the site will again be tested for nitrogen.

TABLE 1 Yield response to variable nitrogen application rates

	Nitrogen application rates (kg/ha)			
	0	20	40	80
	Yield (t/ha)			
	2.9	2.8	3.1	3
	Nitrogen-rich strip (additional 80kg/ha) Yield (t/ha)			
	2.9	2.6	3.2	2.9
Zonal response	Nil	Nil	Nil	Nil
Grain quality	ASW	ASW	ASW	H2

Note: All results are subject to confirmation after the yield maps are fully analysed



Results

There was no visual or yield response to applying nitrogen (see Table 1). The nitrogen-rich strips were not obvious at the time the nitrogen was applied to the plots. This may have been a result of the moderate level of nitrogen in all zones, the dry spring and the time of application.

The quality of the wheat produced was low (ASW due to low protein) in all strips except the high nitrogen strip indicating that insufficient nitrogen was applied. Given the lack of yield response to additional nitrogen, some other factor may have impacted on yield. The economic analysis showed that the addition of nitrogen was unprofitable.

The nitrogen-rich strips were a useful guide to assessing that there would be no response to applying additional nitrogen but not for assessing differing responses in different zones.

SPONSORS

This project is supported by Precision Agriculture Australia's *Training and Demonstration of PA in Practice* (GRDC-funded project SPA00010).

Farmer co-operator: Angus MacNeil

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Precision agriculture demonstrations on sowing and fertiliser rates at *Allendale*, Rand

John Sykes
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Key points

- Using precision agriculture (PA) to apply variable rates of fertiliser is an easy way to test new ideas on farm.
- Precision agriculture can be used to apply different rates of fertliser to different areas of a paddock.
- Wheat responded to applied phosphorus, even though soil tests indicated it had a high level of Colwell P (56mg/kg).

Location: *Allendale*, Rand, NSW

Rainfall:
Annual: 670mm (avg 520mm)
GSR: 225mm (avg 320mm)

Soil:
Type: Red chromosol
pH (H_2O): 5.8
pH ($CaCl_2$): 5.0 – 5.2

Sowing information:
Variety: Ventura, wheat
Sowing date: 23 May 2011
Sowing rate: 70kg/ha
Fertiliser:
- Phosphorus (0, 5, 10 and 20kg/ha)
- Nitrogen (0 and 40kg/ha)

Sowing equipment: Gason 9.2m tine airseeder equipped with press wheels, Hardie sprayer and Marshall spreader. AutoFarm guidance was used on the sowing tractor and a light bar on the spreading tractor.
Treatments: Phosphorus rates of 0–20kg/ha were applied using MAP at sowing. Nitrogen rates of 0–40kg/ha were applied as urea during early August near to growth stage GS32.

Row spacing: 25cm

Paddock history:
2010 — canola

Plot size: 250m x 27.6m

Replicates: nil

Aim

To compare the effects of using variable rates of nitrogen and phosphorus on wheat yield.

Assessments

List: Visual assessment before GS31.

Soil analysis: An EM survey was completed during 2011. A full soil analysis (0–10cm) was completed for the whole paddock during early 2011.

Yield: Determined from the yield map on the header

Results

There was a visual response to phosphorus applied at sowing, which translated into additional yield at harvest. Yield responses were obtained up to 10kg/ha of applied phosphorus. The added net income of applying 10kg/ha of phosphorus was calculated at $37/ha, which translated into a $2.63 return for every $1 spent.

There was no visual or yield response to applying nitrogen. This may have been a result of the dry spring and the time of application.

TABLE 1 Wheat yield response to variable fertiliser application rates

P (kg/ha)	N (kg/ha)	Visual growth response		Grain yield (t/ha)
		P	N	
0	0	Yes	No	3.1
5	0	Yes	No	3.5
	40	Yes	No	3.5
10	0	Yes	No	3.7
	40	No	No	3.6
20	0	Yes	No	3.5
	40	No	No	3.4

SPONSORS

This project is supported by Precision Agriculture Australia's *Training and Demonstration of PA in Practice* (GRDC-funded project SPA00010).

Farmer co-operator: David Wolfenden

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Variable rate nitrogen using satellite imagery at Dookie

Andrew Whitlock
PrecisionAgriculture.com.au

This paper presents the outcomes of the SPAA (Precision Agriculture Australia) trial using satellite imagery for variable rate nitrogen from the 2011 season.

Aim

To determine nitrogen rates using satellite imagery technology.

Background

Growers who are part of the Dookie precision agriculture (PA) discussion group have significant experience in applying variable rates of lime, gypsum, phosphorus and nitrogen. To add to their experience the group wanted to see how effective satellite imagery would be in determining variable nitrogen rates within paddocks.

About the trial

The group participated in a satellite imagery workshop where each participant received a free satellite image map of their property and assistance with converting the map into a nitrogen prescription map.

This report focuses on one member, Mark Harmer, and how he used the satellite imagery information to determine variable nitrogen rates on 'Jack's' paddock (Espada wheat).

The crop assessment was delivered as a normalised difference vegetation index (NDVI) image (5m pixel) from a satellite platform, captured on 2 September 2011 (see Figure 1).

Results

It is critical to note that using NDVI to determine nitrogen prescription is not recommended, unless the crop manager understands why the NDVI readings are low. The main concern is that low NDVI readings might not necessarily

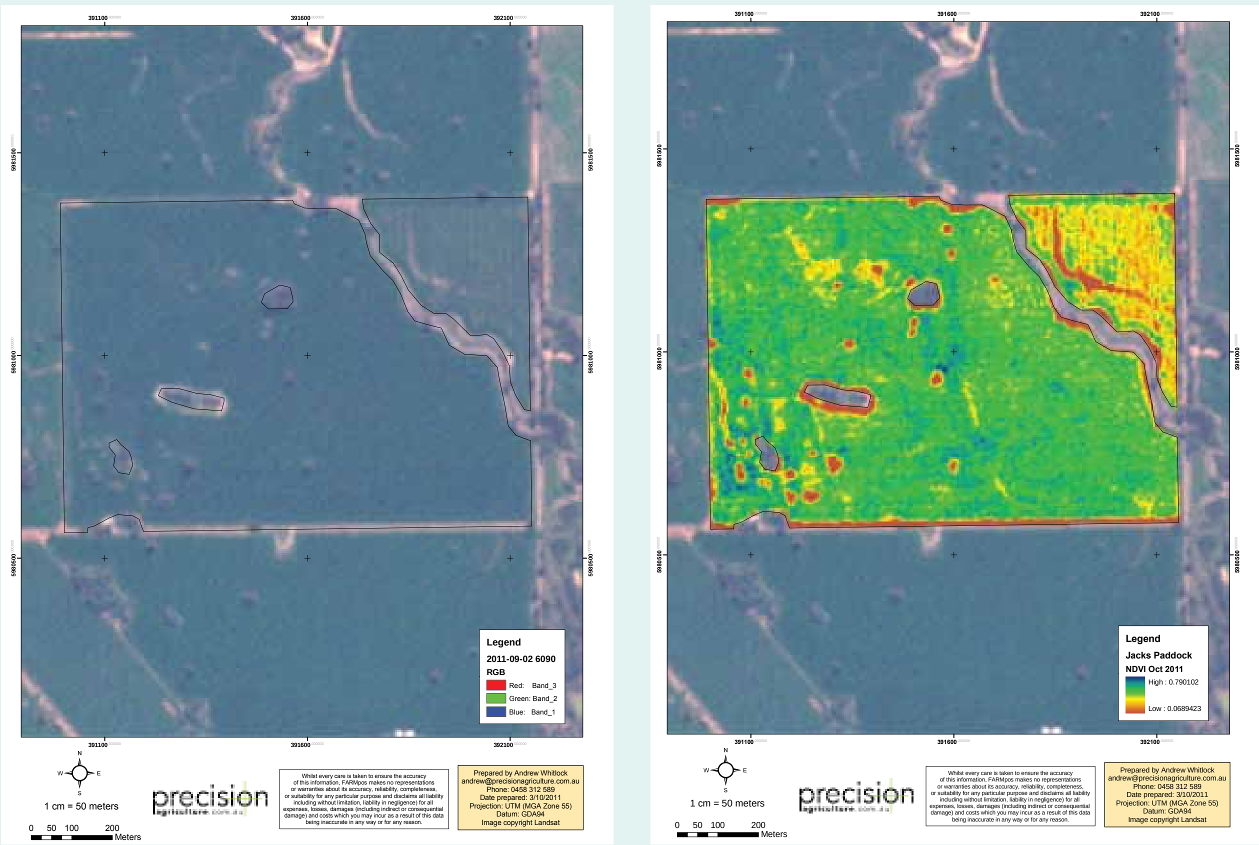

FIGURE 1 RGB (left) and NDVI (right) maps (2 September 2011) for the focus paddock 'Jack's'

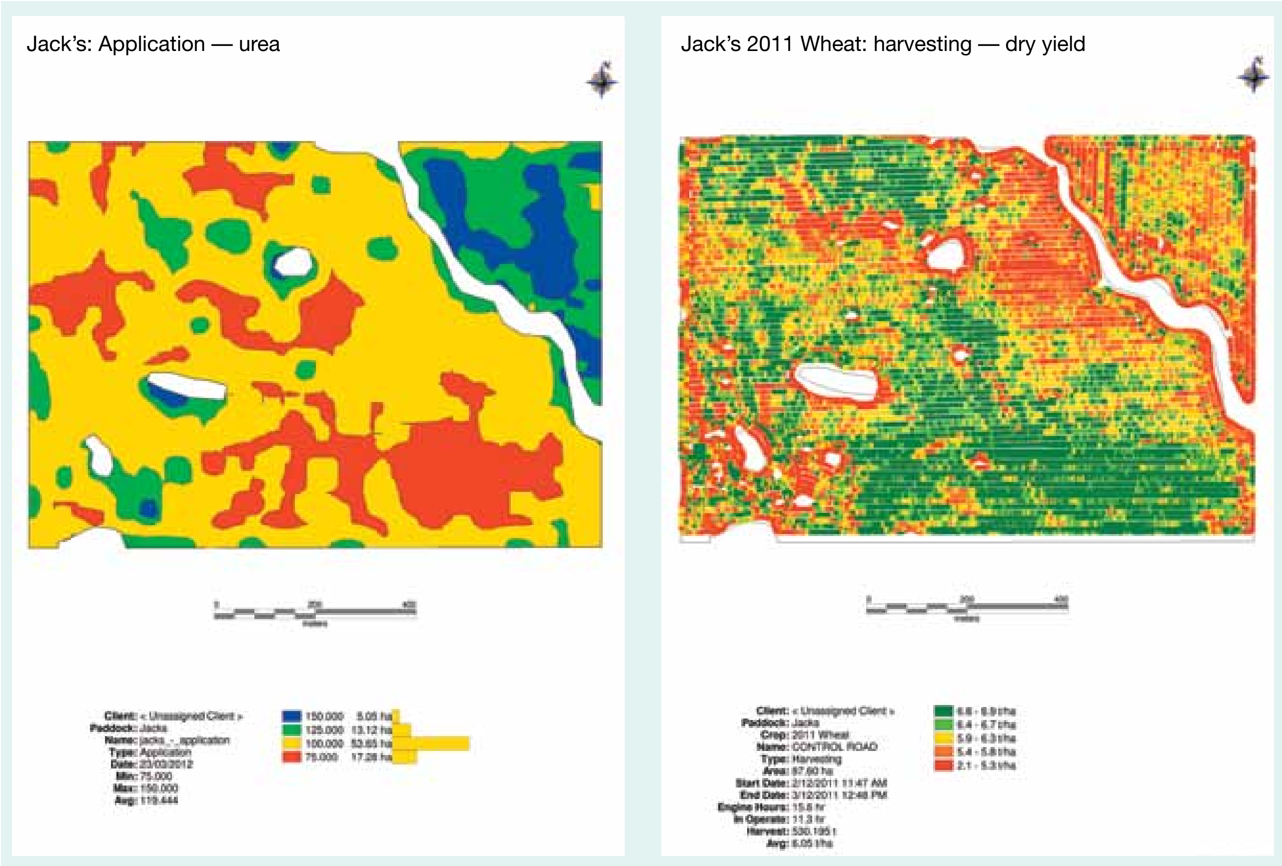

FIGURE 2 'Jack's' nitrogen prescription map (left) and subsequent yield

mean the limiting factor is nitrogen. In addition adding higher nitrogen rates even if nitrogen is limiting may not be economic. The key to using NDVI maps is ground-truthing the reasons for the reduced crop growth.

Mark integrated his paddock knowledge, soil test history and existing management zones to determine his nitrogen application map.

The satellite-based NDVI map was converted into a point data set and then zoned into four categories. Mark was then able to attribute nitrogen rates per zone based on paddock knowledge, seasonal outlook and the NDVI values (see Figure 2).

Variable rates of urea were applied on 18 September 2011, with this being the only nitrogen application for the entire season. The rates varied from 75kg/ha to 150kg/ha, with an overall average rate of 119kg/ha.

Mark used the Agleader Integra display for autosteer, mapping and serial output to the Bogballe spreader.

The NDVI map correlated strongly with final yield (see Figure 2), indicating that the variable rate nitrogen did not level out crop yield. This may have been due to the dry finish to the season. The result did, however, confirm in-season satellite imagery (typically late July, early August) could be used to manage final yield via variable rate intervention.

Mark was happy with the visual correlation to the NDVI map when applying urea, but did not see the yield benefit due to the dry finish.

SPONSORS

This project is supported by Precision Agriculture Australia's *Training and Demonstration of PA in Practice* (GRDC-funded project SPA00010).

Farmer co-operator: Mark Harmer.

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Soil pH mapping at Yarrawonga

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Although precision agriculture (PA) tools and their benefits have been available to Australian grain growers for many years it is estimated that less than one per cent of grain growers use PA 'beyond guidance' in any form.

To address this poor adoption rate, a GRDC-SPAA funded project was established with the aim of increasing the level of adoption of variable rate (VR) technology by participating growers to 30% by 2013. This will be achieved by showing growers how to use PA tools at on-farm demonstration days. This will lift the PA skills of growers and industry and stimulate use of the technology on-farm.

Through the project, PA trials and demonstrations are carried out on growers' properties, which are visited by participating growers throughout the season. Farm walks and workshops are used to discuss and demonstrate the advantages and disadvantages of PA techniques.

This paper presents the outcomes of the SPAA trial soil pH mapping from the 2011 season.

Aim

To compare the effectiveness of soil pH mapping and the VERIS soil pH detector against EM38 zones and satellite imagery.

Background

For many years Riverine Plains members have applied variable rates of lime based mainly on EM38 maps. Members wanted to learn how soil pH could be used to create a lime prescription map and how this would compare with a lime prescription map derived from an EM38 map.

About the trial

The trial was located on the Inchbold's property (paddock 44), 10km south of Yarrawonga. The paddock was in pasture and was mapped using the rapid soil pH mapping system of PrecisionAgriculture.com.au. Soil pH was mapped on a 1ha grid across the entire paddock.

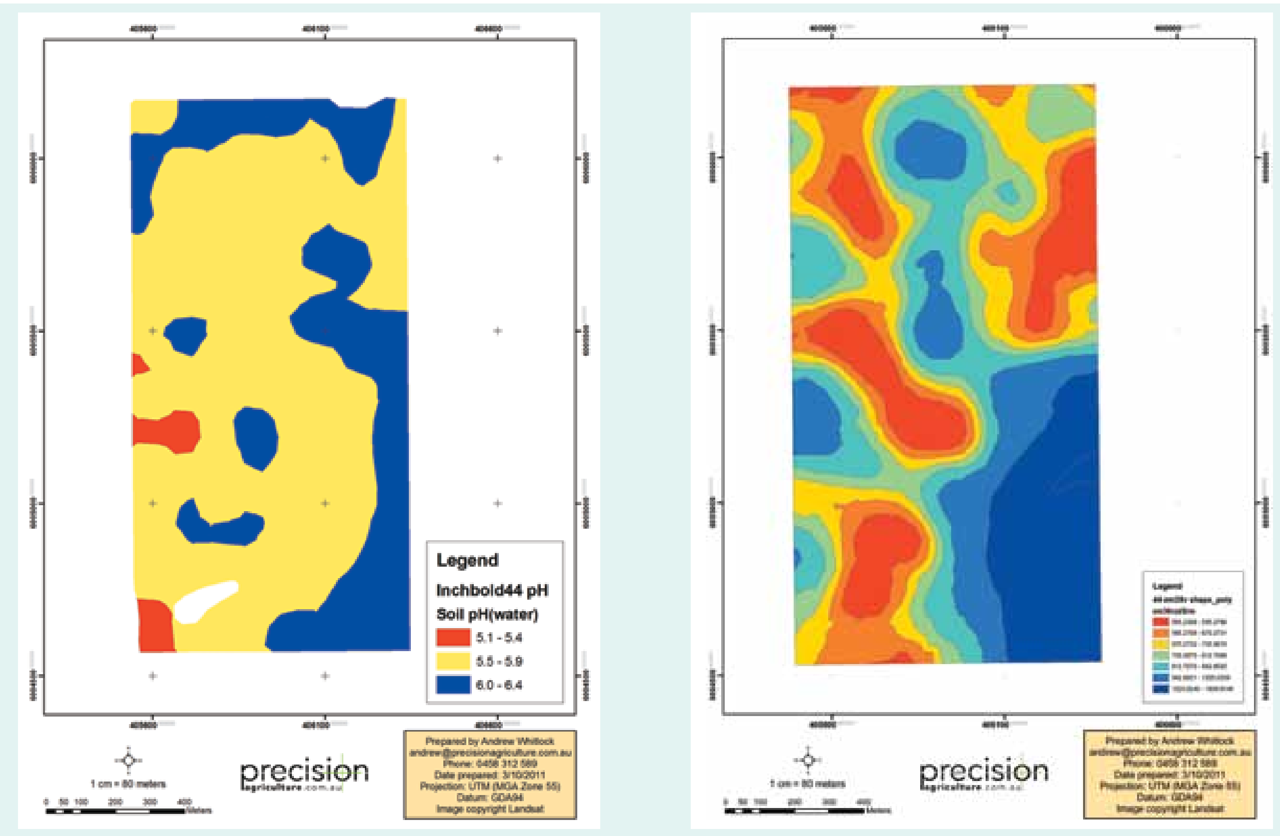

FIGURE 1 Soil pH map from 1ha grid with VERIS Soil pH Detector (left) and EM38 map (right)

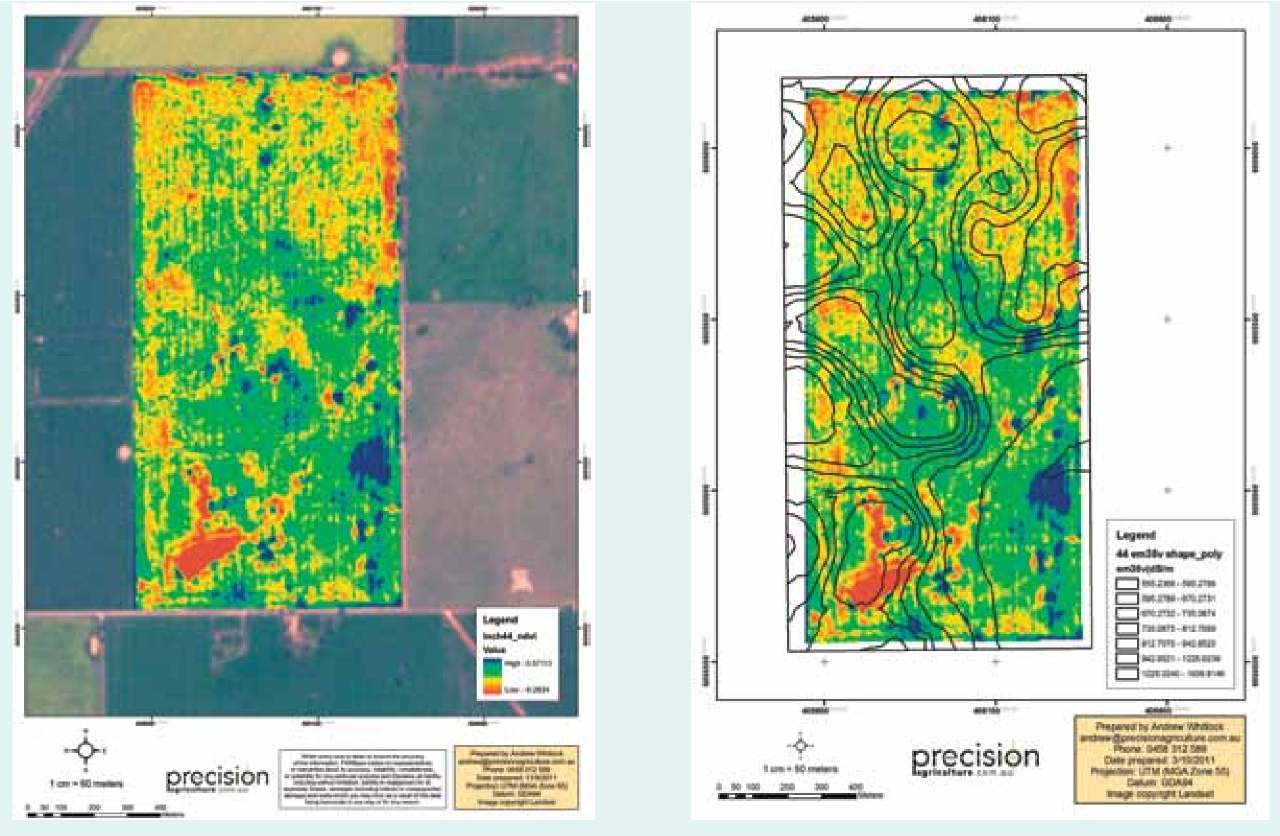

FIGURE 2 Satellite imagery (September 2011): NDVI of pasture (left) and with EM38 overlay (right)

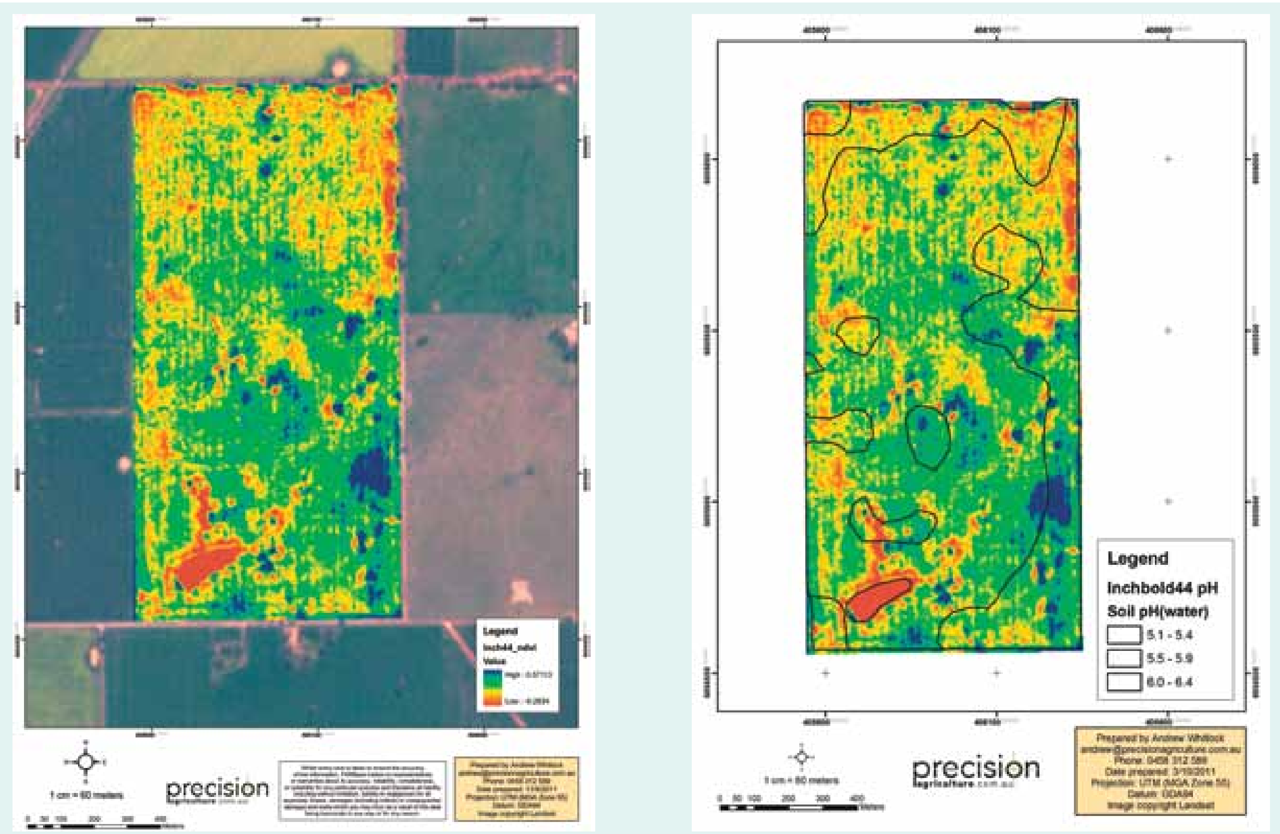

FIGURE 3 Satellite imagery (September 2011): NDVI of pasture (left) and with soil pH overlay (right)

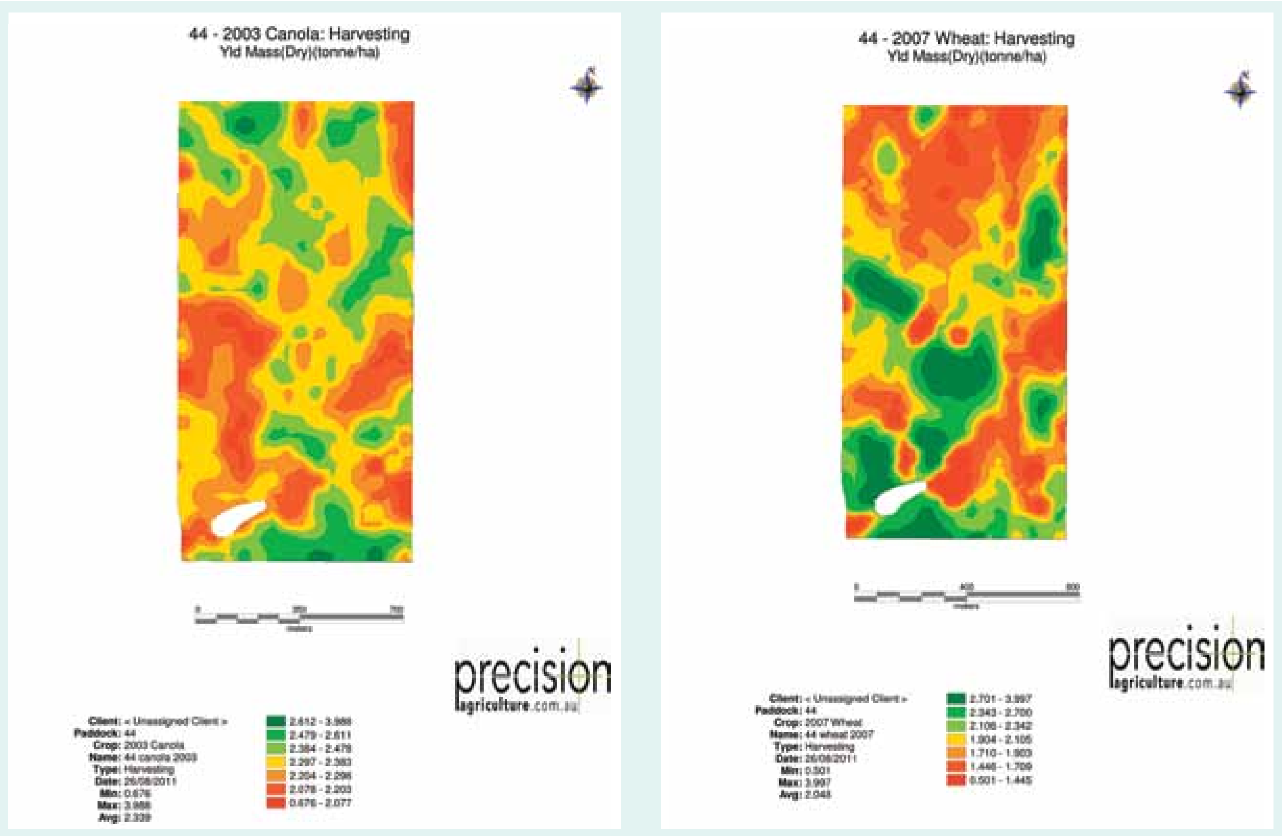

FIGURE 4 Canola yield 2003 (left) and wheat yield 2007 (right)

We compared a historical EM38 map against the soil pH map and a satellite-derived NDVI image (5m pixel) to determine if there was a correlation between pasture biomass and soil pH (see Figure 1).

Results

Similarities emerged between the soil pH map and the EM38 map, especially in the alkaline zone in the southeast of the paddock, which lined up partially to the high EM38 readings (clay soil) (see Figure 2). However the differences between the two maps were significant in terms of creating lime application maps.

The greatest lime savings from using the soil pH map occurred on paddocks considered to be in a 'maintenance' phase, i.e. paddocks with a reasonable lime history only requiring strategic lime applications. Using the soil pH map on these paddocks led to lime savings in the order of 35–65%.

The soil pH maps can also be used to measure the effectiveness of variable lime rates in raising soil pH. A subsequent map is then used to apply a maintenance rate of lime.

As part of the project we ordered a satellite image of the paddock to determine any trends in pasture growth with soil pH and EM38 zones. We also assessed whether the 2003 canola yield map and 2007 wheat yield map correlated with the soil pH, EM38 and the pasture biomass maps (see Figures 3 and 4).

Comparing the different datasets for the paddock indicated that the paddock is highly variable with very little correlation between available datasets.

The project was a success in terms of demonstrating a new technology, which may have a good fit for a group of growers who have been implementing variable rate soil ameliorants for a number of years.

SPONSORS

This project is supported by Precision Agriculture Australia's *Training and Demonstration of PA in Practice* (GRDC-funded project SPA00010).

Farmer co-operators: The Inchbold family.

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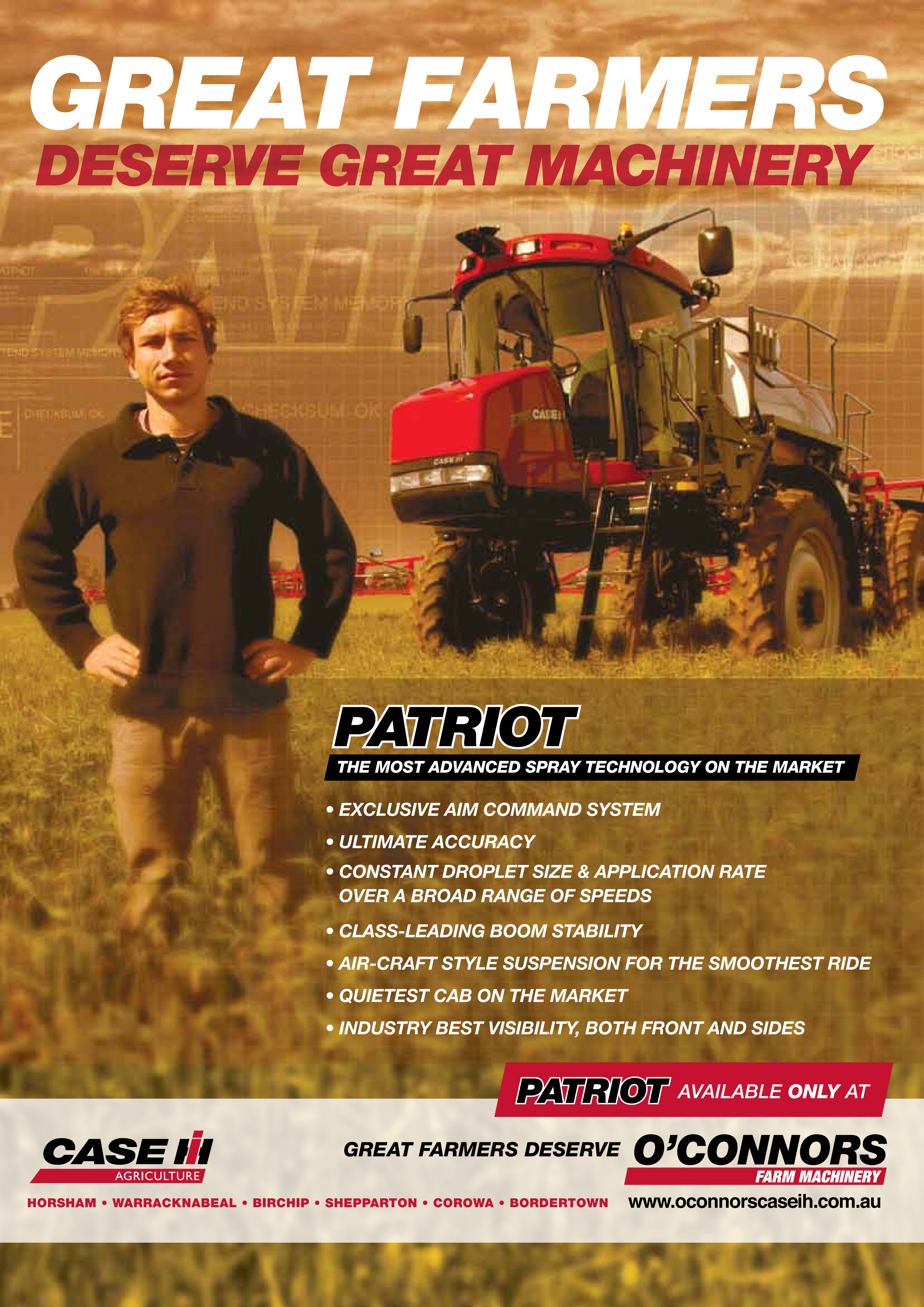
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Rhizobial inoculation can boost crop performance

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Key points

- During 2010, the effect of inoculation on faba beans and lupins was examined in a grower's paddock at Culcairn, NSW that had not grown pulses for at least 10 years. Inoculation increased faba bean grain yield by 1t/ha and increased the amount of shoot nitrogen fixed by both legumes by 130–180kg N/ha.
- The numbers of rhizobia decline in the soil over time, and growers need to consider whether to inoculate pulses based on paddock history and length of time since growing the last legume crop.
- Concentrations of soil mineral nitrogen in 2011 were higher following the inoculated legumes than either the uninoculated treatments or following canola or wheat. But while the grain yields of wheat grown after either faba bean or lupin were significantly higher than after wheat, there was no interaction with added nitrogen fertiliser suggesting that the improvements in yield were not associated with enhanced nitrogen supply.

Background

Legume roots are capable of developing a symbiotic relationship with rhizobial bacteria in the soil. Rhizobia in legume root nodules can fix atmospheric nitrogen (nitrogen gas) and convert it into a form that can be used to support plant growth. The amount of nitrogen fixed is strongly related to legume biomass production. Legumes can fix between 100 to 200kg nitrogen/ha in a growing season when the correct rhizobia are present in high numbers in the soil. It is important to note that correct species of rhizobia must be present. Since the legume species grown in Australia are exotic and the necessary rhizobia for nitrogen fixation do not occur naturally in Australian soils, inoculation with cultures of rhizobia is essential the first time a legume or pulse is grown. However, the population of rhizobia is known to decline in the soil over time if legumes are not regularly sown. At numbers of less than 100 rhizobia per gram of soil, inoculation is usually considered to be necessary to ensure adequate nodulation and sufficient nitrogen fixation to support plant growth. Based on data collated by Ross Ballard (SARDI) from numerous Australian published studies on numbers of soil rhizobia capable of forming nodules on chickpeas, peas or lupins, it will likely be necessary to re-inoculate with rhizobia if it has been more than six years since the last legume crop to ensure the legume will be able to fix nitrogen. A study was undertaken during 2010 to investigate the effect of rhizobial inoculation on nitrogen fixation and crop performance in different environments.

Aims

To assess the impact of rhizobial inoculation on the growth, nitrogen fixation and grain yield of faba beans and lupins in a paddock with no recent history of growing legumes, and to determine whether there was any subsequent effect of the inoculation treatment on soil mineral nitrogen and grain yield by a following wheat crop.

Method

During 2010, the effect of inoculation on faba beans (*Farah*) and lupins (*Jindalee*) were examined in two separate blocks at Culcairn, NSW where pulses had not been grown for at least 10 years. The seeds sown into half the legume plots were inoculated using appropriate commercial peat inoculants, and nodulation, nitrogen fixation, shoot biomass and grain yield were subsequently assessed with and without inoculation. Each treatment was replicated six times. Replicated plots of canola and wheat were included as non-legume controls (only data for nil nitrogen fertiliser presented).

During May 2011 soil samples (0–1.7m) were collected for measurements of soil mineral nitrogen, and wheat (Lincoln) was sown over the previous year's treatments. Each experimental plot was split for plus (50kg nitrogen/ha as urea) and minus nitrogen fertiliser, and grain yields were determined at the end of the growing season.

Results

There were large differences in root nodulation between the inoculated and uninoculated treatments in both species, but the effect was most marked for faba beans where nodules were only occasionally found on lateral roots of the



uninoculated plants, whereas there was profuse nodulation of the crown of the tap root with inoculation (data not shown). The results outlined in Table 1 indicated there were large, significant increases in shoot dry matter, the amounts of nitrogen fixed over the growing season (increased by 5–9 fold), and the amount of shoot nitrogen fixed per tonne of dry matter accumulated (increased by 3–4 fold) for both the faba beans and the lupins due to inoculation. Inoculation also significantly improved grain yield in faba beans by more than 50%, but there was no measurable effect on lupin yield (see Table 1). The additional 1.0 tonne of faba beans grain harvested was worth around $400/ha and was achieved at a cost of about $4/ha in rhizobial inoculant.

Legume inoculation significantly increased the concentration of mineral nitrogen when sowing wheat during 2011 compared with the uninoculated faba bean treatment and the unfertilised canola or wheat grown during 2010 (see Table 2). However, by the end of the growing season there were no interactions in grain yield between legumes that were inoculated or not during 2010, or whether nitrogen fertiliser was applied to wheat or not during 2011, so the data has been combined in Table 3 for ease of presentation. Wheat yields following faba beans or lupins proved to be significantly greater than wheat-wheat, and canola-wheat sequences in the faba beans block, but wheat yield following canola could not be statistically separated from lupin-wheat in the lupin block in a different part of the paddock.

Observations and comments:

Growers need to consider the paddock history and length of time since the last legume when considering whether to inoculate their legume crops. Since rhizobial numbers slowly decline in the soil over time when legumes are not regularly sown, there could be a benefit of inoculation after a prolonged break between legume crops. In addition, rhizobia survive poorly in acid soils, so inoculation is likely to be required more frequently in acid soils. Clearly there was evidence that low rhizobial numbers and sub-optimal nitrogen fixation limited the performance of faba bean at the

TABLE 1 Effects of inoculation on shoot dry matter (DM), grain yield and nitrogen fixation by faba beans or lupins at Culcairn, NSW during 2010

Species	Inoculation	Shoot DM (t/ha)	Grain yield (t/ha)	Shoot nitrogen fixed	
				(kg N/ha)	(kg N/ t DM)
Faba beans	-	5.97	1.75	23	4
Faba beans	+	11.61	2.70	202	17
Lupins	-	7.76	3.50	37	5
Lupins	+	9.18	3.70	169	18
LSD (P<0.05)					
Faba bean x inoculation		2.40	0.44	56	2.6
Lupin x inoculation		NS	NS	56	3.3

TABLE 2 Effects of pulses grown with or without inoculation, or canola and wheat grown with or without nitrogen fertiliser during 2010 on soil mineral nitrogen (0–1.7m) measured in May 2011 at Culcairn, NSW

Species	Inoculation or nitrogen fertiliser	Soil mineral nitrogen (kg N/ha)	Species	Inoculation or nitrogen fertiliser	Soil mineral nitrogen (kg N/ha)
Faba beans	-	203b*	Lupins	-	191ab*
Faba beans	+	252a	Lupins	+	209a
Canola	-	165b	Canola	-	180b
Wheat	-	158b	Wheat	-	120c
LSD (P<0.05)		48			27
*Figures followed by different letters differ significantly					

TABLE 3 Effect of pulses, canola or wheat grown during 2010 on subsequent wheat yields at Culcairn, NSW during 2011

Species	Wheat yield (t/ha)	Species	Wheat yield (t/ha)
Faba beans	5.37a*	Lupins	5.39a*
Canola	4.56b	Canola	4.92ab
Wheat	4.61b	Wheat	4.50b
LSD (P<0.05)	0.66		0.72
*Figures followed by different letters differ significantly			

Culcairn site during 2010 (see Table 1). When considering whether to inoculate pulse crops or not it is useful to keep in mind that while field peas, lentils, faba beans and vetch can nodulate with the same rhizobia species, a different rhizobia species is required for lupins and a different species again for chickpeas. So it is important to look at the time interval between legumes that nodulate with the same rhizobial species.

The increased nitrogen fixation that occurred with inoculation was reflected in measurably higher concentrations of soil mineral nitrogen during 2011 compared with the uninoculated treatments or where either canola or wheat had previously been grown (see Table 2). However, the fact that there was no effect of applications of an additional 50kg fertiliser-nitrogen/ha on subsequent wheat yields during 2011 (see Table 3) implied that the higher grain yields observed after faba beans and lupins were not directly associated with improved nitrogen nutrition.

SPONSORS

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Naparoo wheat grazing demonstration at Tungamah

Dale Grey[1], Sandy Quinlivan[2] and Alison Frischke[3]
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[2] Formerly DPI Birchip
[3] Birchip Cropping Group

Key point

- Grazing Naparoo wheat reduced grain yield by up to 19%.

Location: Tungamah, Victoria

Rainfall:
Annual: 550mm (avg 510mm)
GSR: 224mm (avg 334mm)

Soil:
Type: Brown loam over heavy grey clay

Sowing information:
Variety: Naparoo wheat
Sowing date: 17 April 2011
Sowing rate: 90kg/ha
Fertiliser: 110 kg/ha MAP; 12 kg/ha foliar nitrogen; 60 kg/ha nitrogen as urea
Treatments: Grazed (74DSE/ha) and ungrazed

Row spacing: 30cm

Paddock history:
2010 — canola

Plot size: 6m x 6m

Replicates: 3

Photo: Dale Grey

Aim

To determine the effect of grazing on grain yield of Naparoo wheat.

Method

A dryland demonstration site was established at Tungamah to determine the impact of grazing on wheat yield. Naparoo wheat was sown into moisture on 17 April 2011 at 90kg/ha with 110kg/ha MAP on a 30cm row spacing in a 24ha paddock.

Naparoo was chosen for its high biomass production, rust resistance and its winter habit for grazing. The crop was top dressed on 18 May 2011 with 12kg/ha foliar nitrogen at GS14 (four leaf). Dry matter (DM) cuts were taken on 1 July 2011 at GS16.5 to determine available biomass.

The crop was grazed on 2 July 2011 by 400 ewes in lamb (38 DSE/ha) but removed on 3 July 2011 due to two ewe deaths. The ewes were lambed out in another paddock. The 400 ewes with 400 lambs (74 DSE/ha) were reintroduced on 25 July 2011 for three weeks. The crop was then top dressed on 15 August 2011 with 60kg/ha nitrogen as urea. The crop was grown to maturity and harvested for grain using a plot header.

Results

The ungrazed paddock contained 596kg/ha DM (see Table 1) at 6.5 leaf stage, 12 tillers, no nodes. Plant establishment was fair due to the dry autumn start with the crop looking thin but tillering well. The effect of grazing varied across the paddock. In two areas of the paddock the yield loss was marked, while in another area there was no yield difference between grazed and ungrazed plots. On average the yield loss was 19% (see Table 1) but this was not statistically significant across the trial. Protein levels were similar for grazed and ungrazed treatments.

TABLE 1 Dry matter and grain yield results for grazed and ungrazed Naparoo wheat

Treatment	Dry matter (kg/ha)	Yield (t/ha)	Screenings (%)	Protein (%)
Grazed	596	4.05	1.1	9.3
Ungrazed		4.98	0.7	9.2
		P = 0.193 lsd = 2.07 cv% = 13		



Observations and comments

The sheep grazed an estimated 700kg of DM/ha during the three-week grazing period. The profitability of the paddock was not compromised by grazing and provided stock with feed during July.

Cereal crops grazed during the vegetative stage represent a high-quality feed source but are low in salt and high in potassium, which can reduce magnesium absorption in the rumen. Animals grazing cereal crops (especially wheat) require supplementation with a lick made of equal parts of magnesium oxide, ground limestone and salt. The limestone will provide calcium to pregnant and lactating ewes.

It is important to introduce animals to all new feeds gradually and provide supplementary hay. A gradual introduction will minimise the potential for scouring as the rumen bacteria adapt to the new feed source, while the hay will provide adequate fibre to assist rumen function. Careful introduction to feed on sunny days (avoid overcast conditions) and access to hay will also avoid nitrate poisoning when grazing oat and canola crops, particularly for more susceptible livestock such as heavily pregnant and lactating ewes and cows.

SPONSORS

This project is funded by the Grains Research and Development Corporation (GRDC) and Caring for our Country through the northern Victoria *Grain and Graze 2* (GRDC project BWB00018).

Thanks also go to farmer co-operators Josh and Jenny Buerckner.

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Canola mowing demonstration at Telford

Dale Grey[1] and Sandy Quinlivan[2]
[1] DPI Victoria, Cobram
[2] Formerly DPI Birchip

Key points

- Simulated grazing (mowing) reduced canola grain yield by 17%.
- The acceptability of yield loss in return for additional feed in the form of dry matter (DM) will depend on grain and livestock prices.
- The trial results highlight the importance of timely grazing management.

Location: Telford, Victoria

Rainfall:
Annual: 649mm (avg 508mm)
GSR: 209mm (avg 328mm)

Soil:
Type: Red loam over medium clay

Sowing information:
Variety: Roundup ready hybrid canola
Sowing date: 16 April 2011
Sowing rate: 2.2kg/ha
Treatments: Simulated grazing (mown once to 6cm)

Row spacing: 25cm

Paddock history:
2010 — wheat

Plot size: 6m x 6m

Replicates: 3

Aim

To determine the impact on final grain yield from grazing canola grown for grain and fodder.

Method

A dryland demonstration site was established at Telford to determine the effect of grazing canola on final grain yield. Hyola 601RR Roundup Ready Hybrid canola was sown on 16 April 2011 at 2.2kg/ha at a 25cm row spacing.

Plant counts were taken at establishment to determine plant densities. The plants were mown on 1 July 2011 to within 6cm of the ground to simulate a grazing event and dry matter (DM) cuts taken to determine the amount of biomass removed. The crop was then grown to maturity and the paddock was windrowed on 1 November 2011.

Plots were harvested on 14 November 2011 and the grain yields of mown (grazed) and ungrazed (control) areas were compared.

Results

Average plant density across the plots at establishment was 15 plants/m^2. On 1 July 2011 the plants were 20cm high, 35cm in diameter and at about 90% ground cover. The plants were just starting to bud and run up. Mowing (simulating grazing) removed 700kg/ha DM, including some developing buds (see Table 1). The grazing simulation reduced the canola grain yield by 17% (see Table 1, P = 0.007) compared with the control plot.

The oil content of the grazed crop was 2.3% higher than the control.

Observations and comments

Grazing significantly reduced grain yield, possibly due to the removal of buds leading to a reduced pod number and a diminished potential yield.

Although yield reduction was significant, the percentage reduction is still surprisingly low considering how late the plants were mown.

TABLE 1 Dry matter and grain yields of grazed and ungrazed canola

Treatment	DM (kg/ha)	Oil (%)	Yield (t/ha)
Grazed	700	49.6	2.21
Ungrazed	–	47.3	2.65
LSD			**0.17**
CV%			**2.0**
P			**0.007**



Canola crop at Telford. Mown plants (foreground) and ungrazed plants (background).

The acceptability of a 17% yield loss in exchange for 700kg DM/ha for grazing livestock will depend on the prices of grain, supplementary feed and livestock. This amount of DM could be converted into 88kg of lamb growth (@ feed conversion efficiency of 8:1) and be worth $220/ha (@ $2.50 kg liveweight, 55% dressing percentage). For the canola crop, 440kg of canola worth $550/t would equate to a loss of $242/ha. As the paddock was mown, rather than grazed by animals, the results do not take into account the selective grazing habits of livestock. In addition, animals return some nutrients to the paddock and this was not accounted for. Spring 2011 was cool with sufficient moisture stored in the soil profile, which probably aided the recovery of the mown crop. The early sowing date meant the mown crop still flowered in a favourable window, possibly assisting grain fill.

SPONSORS

This project is supported by the Northern Victoria *Grain and Graze 2* project, (BWB00018) funded by the Grains Research and Development Corporation and Caring for our Country. Thanks also go to farmer cooperators, the Inchbold family.

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Wedgetail wheat grazing demonstration at Wilby

Dale Grey[1] and Sandy Quinlivan[2]
[1] DPI Victoria, Cobram
[2] Formerly DPI Birchip

Key points

- Wedgetail provided good grazing for yearling steers.
- The grazing effect on grain yield was not determined, however the grazed crop recovered to yield 4t/ha.

Location: Wilby, Victoria

Rainfall:
Annual: 649mm (avg 508mm)
GSR: 209mm (avg 328mm)

Soil:
Type: Brown loam over medium brown clay

Sowing information:
Variety: Wedgetail wheat
Sowing date: 5 April 2011
Sowing rate: 70kg/ha
Fertiliser: 90 kg/ha MAP; 130 kg/ha nitrogen as urea (split application)
Treatments: Grazed (49 DSE/ha) and ungrazed

Row spacing: 25cm

Paddock history:
2010 — wheat
2009 — canola

Plot size: 6m x 6m

Replicates: 3

Aim

The aim of the trial was to:

1. Determine the grazing value of Wedgetail wheat for yearling steers.
2. Determine the impact of grazing on the grain yield of Wedgetail wheat

Method

A dryland demonstration site was established at Wilby, Victoria, to determine the effect of grazing on wheat yield. Wedgetail wheat was sown on 5 April 2011 at 70kg/ha with 90kg/ha MAP on a 25cm spacing. Wedgetail was chosen for its grain quality and capacity to be grazed during early winter. Dry matter (DM) cuts were taken at GS30 to determine available biomass. On 1 August 2011, 190 Angus yearlings were introduced for 27 days (49 DSE/ha) and removed just as the crop nodes were leaving the ground (GS30-31). Following cattle removal the paddock was top dressed twice with a total amount of 130kg/ha nitrogen as urea. The crop was then grown to maturity and harvested for grain.

Photo: Rohan Pay



TABLE 1 Dry matter and yield results for grazed and ungrazed Wedgetail wheat

Treatment	DM (kg/ha)	Yield (t/ha)	Protein (%)
Ungrazed	1451	na	–
Grazed	–	4.0	12.8

Results

At the time of grazing there was 1451kg/ha DM (see Table 1). Plants were at seven-leaf, eight-tillers growth stage (GS30) and on most plants the node was not visible. On some advanced plants the node was 0.5cm to 1.0cm off the ground. During the grazing period the cattle trampled the exclusion cages so an ungrazed yield was not attainable. After the grazing period, most nodes were 1–2cm off the ground.

Observations and comments

The cattle grazing Wedgetail wheat were estimated to have eaten 1100kg of DM and did not graze the crop into the ground. This feed potentially grew 140kg of beef/ha (assuming a feed conversion rate of 8:1). Due to the cattle trampling the exclusion cages it was not possible to determine the yield of the ungrazed plots.

SPONSORS

This project is funded by the GRDC and Caring for our Country through the northern Victoria *Grain and Graze 2* (GRDC project BWB00018).

Thanks also go to the Inchbold family, as farmer co-operators.

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Photo: Rohan Pay

2011–2012 summer forage trial at Tungamah

Dale Grey
DPI Victoria, Cobram

Key points

- Forage sorghum and millets achieved the highest yields (5–30 tonnes of dry matter (DM) per hectare) during the summer forage trial of 2011–2012.
- Lab lab was the most promising forage legume although DM yields were low.
- Other legumes along with the brassicas and winter cereals either failed to emerge or achieved only sparse plant numbers.

Aim

The aim of the trial was to evaluate whether growers could make productive use of the out-of-season rainfall that has fallen during the past few summers and which is predicted to become more common.

The productivity of summer and winter forage species was assessed during summer as part of the *Grain and Graze 2* adaptive forage program.

Method

Weeds were knocked down with glyphosate before sowing the trial forage species. The trial was sown into marginal moisture on 15 December 2011 using a cone seeder. Dry matter (DM) cuts were taken on 4 April 2012 on those plots that had sufficient evenness of growth.

The species planted were:

- Shirohie (Japanese) millet sown at 10kg/ha
- French grain millet sown at 10kg/ha
- Pearl grain millet sown at 10kg/ha
- Sprint forage sorghum sown at 10kg/ha
- Hunnisweet forage sorghum sown at 10kg/ha
- Pacer grain sorghum sown at 10kg/ha
- Maize sown at 25kg/ha
- Wedgetail winter wheat sown at two sowing rates — 60kg/ha and 120kg/ha.
- Bouncer hybrid brassica (turnip x Chinese cabbage) sown at 4kg/ha
- Taurus winter habit canola sown at 2kg/ha
- L023B-23 soybean sown at 50kg/ha
- Djakal soybean sown at 50kg/ha
- Emerald mungbeans sown at 20kg/ha
- Butterfly peas sown at 25kg/ha
- Pigeon pea sown at 10kg/ha
- Ronagi lab lab sown at 25kg/ha
- Red Caloona cow pea sown at 15kg/ha.

Observations and comments

Plant emergence was patchy as no significant rain fell during December 2011. Maize, soybean and pearl millet failed to establish. By early February 2012 some of the forage grasses were 30cm tall while the butterfly peas had not emerged at all. The Boosey Creek flooded during early March covering the plots for about two weeks. Butterfly peas emerged after the flood and grew rapidly. Mungbeans, wheat, grain sorghum, pigeon peas and the brassicas were abandoned due to poor plant numbers.

Despite the late sowing and the flooding several forage cereals yielded well (see Table 1). Lab lab was the most impressive of the forage legumes suggesting it was quite tough and that with a better establishment could show promise. The trial results were highly variable as shown by a high coefficient of variation (CV) of 60%, which ideally

TABLE 1 Dry matter yield for a range of summer fodder crops at Tungamah

Fodder crop	DM yield (t/ha)	DM (%)
Sprint forage sorghum	8.5	25.8
French millet	5.1	31.0
Hunnisweet forage sorghum	4.8	20.5
Japanese millet	2.2	22.9
Lab lab forage legume	1.7	23.1
Cow pea forage legume	1.0	20.6
Butterfly pea forage legume	0.5	22.8
LSD 0.05	**3.8**	**5.2**
CV%	**60.7**	**12.5**
P	**0.007**	**0.016**



Sprint forage sorghum showing two metres of growth

needs to be below 20%. The DM percentage varies with plant maturity with French millet in late grain fill by the end of the trial but Hunnisweet sorghum still vegetative with large green leaves.

The results are similar to the DM production achieved during the 2010–11 summer forage trials, where forage sorghum yielded the highest followed by the millets.

SPONSORS

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Thanks also go to farmer co-operators Josh and Jenny Buerckner.

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Pre-emergent herbicides for managing herbicide-resistant ryegrass

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Key points

- Trifluralin resistance is increasing in annual ryegrass.
- New pre-emergent herbicides have been registered that will control resistant ryegrass.
- Rotation of pre-emergent herbicides is essential to delay resistance.

Aim

The increasing incidence of trifluralin resistance in annual ryegrass means there is a need to use other pre-emergent herbicides to manage herbicide-resistant annual ryegrass in no-till sowing systems. This trial was done to identify appropriate pre-emergent herbicides and mixtures for controlling trifluralin-resistant annual ryegrass.

Method

The trial was sown to Scout wheat at Freeling, South Australia during 2011 and organised as a randomised complete block design with plots 2m x 10m on 22cm row spacings using a knife-point/press wheel plot seeder. Pre-sowing herbicides were applied within an hour of sowing and incorporated by sowing (IBS). Weed counts were taken during the season and the number of ryegrass panicles quantified at harvest.

Herbicides and rates used were: TriflurX® (2L/ha); TriflurX (1.5L/ha) + Avadex Xtra® (1.6L/ha); Boxer Gold® (2.5L/ha); Avadex Xtra (3L/ha); Sakura® (118g/ha); and Sakura (118g/ha) + Avadex Xtra (1L/ha).

Results

The trial was established in a moist seedbed, and experienced favourable growing conditions during much of the 2011 season, culminating in above-average grain yield. Rainfall was above average for winter, with relatively mild temperatures experienced for much of this part of the year, resulting in a vigorous crop and rapid crop development. Early spring was dry.

Crop safety was generally good for all herbicides except the 2L/ha TriflurX treatment. This treatment reduced crop emergence significantly and reduced crop vigour marginally.

The annual ryegrass at the site was only marginally resistant to trifluralin. This, along with strong crop competition and ideal moisture conditions early, meant that all herbicides worked adequately. TriflurX and TriflurX + Avadex Xtra had the lowest levels of annual ryegrass control. Sakura + Avadex Xtra had the highest level of control (see Figure 1). However, there was only 16% difference in control between the worst performing and best performing treatments.

All herbicide treatments reduced annual ryegrass panicle density relative to the untreated control (see Figure 2). Boxer Gold, Sakura and Sakura + Avadex Xtra had the lowest number of panicles. Strong competition from the crop and the dry spring meant that many annual ryegrass plants did not produce seed.

The number of annual ryegrass plants emerging from the crop canopy, and hence likely to produce the most seed, was also counted. All herbicide treatments had much lower numbers of ryegrass panicles emerging from the crop canopy than the nil treatment with the Sakura treatments having none. This demonstrates the value of an effective pre-emergent herbicide and strong crop competition in managing annual ryegrass populations.

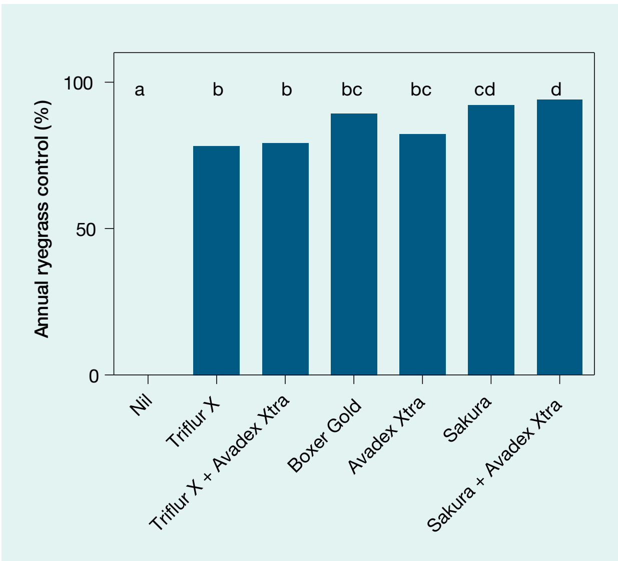

FIGURE 1 Annual ryegrass control by pre-emergent herbicides assessed 50 days after sowing

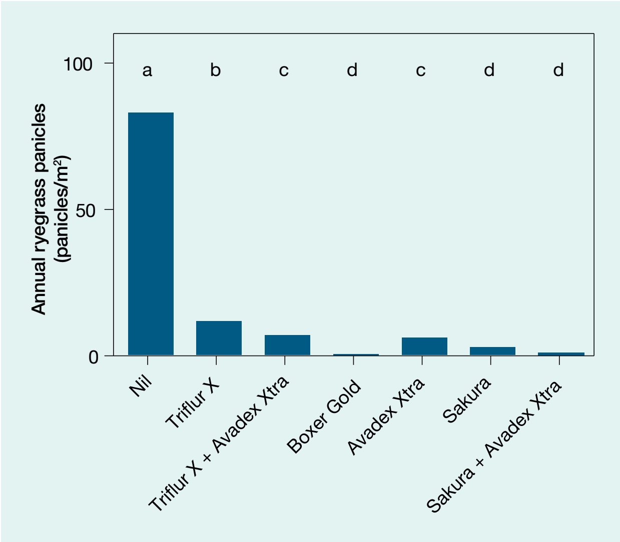

FIGURE 2 Annual ryegrass panicle production measured at crop harvest

Observations and comments

Weed surveys of cropped paddocks in SA and Victoria indicate an increasing number of paddocks containing trifluralin-resistant annual ryegrass. The presence of trifluralin-resistant annual ryegrass requires that other pre-emergent herbicides are used in no-till sowing systems. During recent years, several new herbicides or new uses have become available including Boxer Gold (Groups J + K), Sakura (Group K) and Avadex Xtra (Group J) for managing annual ryegrass in IBS systems.

These herbicides have different modes of action and attributes to trifluralin. Boxer Gold and Sakura are more water soluble and hence move further in the profile. This allows some control of annual ryegrass in the crop row. Boxer Gold has low persistence and where spring is wet, annual ryegrass will germinate late. Sakura has longer persistence, but requires more moisture to activate than Boxer Gold. When the season start is dry, Boxer Gold will provide better early control. Avadex Xtra does not provide as consistent a level of control as seen with Boxer Gold and Sakura. However, it does prove to be an excellent mixing partner with other pre-emergent herbicides, often providing additional control.

The new pre-emergent herbicides are from two modes of action only. Therefore, there is a need to rotate between these modes of action to delay the onset of resistance to the new herbicides. Neither Boxer Gold, nor Sakura can be used safely in canola, so other pre-emergent herbicides, such as trifluralin + Avadex Xtra, will be required for canola. Adopting the new pre-emergent herbicides for some crops on the farm now will help preserve the utility of trifluralin.

SPONSORS

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Norong stubble retention demonstration

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Key points

- The incorporated stubble treatment yielded the highest during 2011.
- The standing stubble treatment yielded the least during 2011.

Location: Norong, Victoria

Rainfall:
Annual: 652mm (avg 538mm)
GSR: 286mm (avg 350mm)

Soil:
Type: Grey loam over medium clay
pH ($CaCl_2$): 4.8

Sowing information:
Variety: Gregory⽬
Sowing date: 14 May 2011
Sowing rate: 85kg/ha
Fertiliser: 80kg MAP
Sowing equipment: Conserva Pak™ air seeder
Treatments: Stubble residue left standing or mulched, burnt or incorporated before sowing

Row spacing: 30cm

Paddock history:
2010 — canola
2009 — triticale
2008 — wheat

Plot size: 100m x 9m

Aim

To test the effect of different stubble treatments on crop performance over time.

Method

The effect of four different stubble management practices (mulched, burnt, standing and incorporated) on grain yield was monitored at the Norong demonstration site. Stubble treatments were imposed during autumn. Gregory⽬ wheat was sown into canola stubble with a Conserva Pak™ air seeder on 14 May 2011 at a sowing rate of 85kg/ha on 30cm spacing. The 2010 canola crop and the wet summer resulted in very little stubble being present, except for some dead summer weeds. The paddock was top dressed at mid-tillering with 80kg/ha nitrogen applied as urea. Harvest was on 8 December 2011 using an auto header and grain weighed with a mobile weigh bin.

Results

TABLE 1 Impact of stubble treatments on crop performance

Treatment	Mulched (Coolamon harrows)	Burnt	Standing	Mulched/ incorporated
2011 wheat	5.0	5.0	4.4	***5.4***
2010 canola	Not harvested			
2009 triticale	2.7	2.6	***3.0***	2.4
2008 wheat	***3.3***	***3.3***	3.2	3.2
2007 lupins	***0.5***	0.4	***0.5***	0.4
2006 triticale	0.6	***1.3***	0.5	0.3

Photo: Catriona Nicholls



Observations and comments

Overall the site yielded very well with the 'incorporated' plot yielding the highest during 2011. The 'standing stubble' plot yielded significantly less. The Norong trial site was in its sixth year of stubble treatments during 2011. Despite using a double-knock and a modern pre-emergent chemical mix, annual ryegrass control continues to be an issue at the Norong site and a decision has been made to retire it to pasture. Ryegrass populations were highest in standing stubble, which may account for the lower yield. The incorporated treatment had the least ryegrass, but could also have had more mineralisation and hence more nitrogen available during the dry spring.

The stubble treatments have varied from year to year in their impact on crop performance due partly to dry seasons, the amount of stored soil moisture, weeds and poor plant establishment.

SPONSORS

Boorhaman LANDCARE Group and farmer co-operator Neville Tweddle.

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Reducing rhizoctonia disease in cereals

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Key points

- Barley and wheat crops are at greatest risk of rhizoctonia, but other crops are also affected.
- Cereals (and grasses) are the main hosts of the disease.
- Grass-free canola and grass-free pasture reduce rhizoctonia levels.
- Rhizoctonia inoculum is reduced by frequent summer rainfall.
- Control summer weeds to further reduce rhizoctonia inoculum.
- Control autumn ‘green bridge’ to prevent inoculum build-up.
- Sow early to minimise damage to the seedlings.
- Disturb soil below seed to encourage rapid root growth through soil profile.
- Consider fungicides (more options are under development).
- Minimise nitrogen deficiency — deep band nitrogen and leave stubble on soil surface.
- Avoid using low-disturbance disc seeders in high-risk paddocks.
- Disease suppression can develop in long-term stubble retention systems.

Introduction

Rhizoctonia bare patch caused by *Rhizoctonia solani* Kühn AG-8 is a difficult disease to manage, but current research projects funded by the Grains Research and Development corporation (GRDC) and the South Australian Grain Industry Trust (SAGIT) are making significant progress towards getting on top of this disease.

Rhizoctonia mainly occurs in the low to medium rainfall regions of southern Australia, particularly in sandy soils, however its distribution can extend into higher rainfall districts such as the western slopes in southern NSW (see Figures 1a and 1b). Annual losses are estimated to be around $59 million in wheat and barley (Murray and Brennan, 2009).

Rhizoctonia has generally been considered a pathogen of seedlings and not greatly affected by rotation, however new information shows it can attack crops throughout the growing season. The good news is that rotations can have a bigger impact than previously thought on reducing the disease.

The current research program aims to improve disease prediction, reliability of existing control strategies and support development of new control methods including banding fungicides as well as assisting to fast track registration of new fungicides that have greater efficacy.

Observations and comments

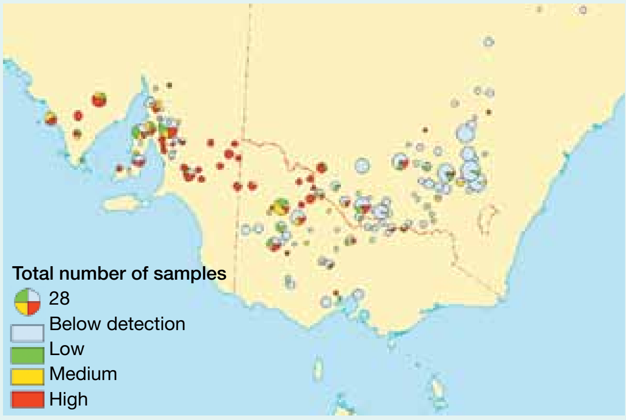
Rhizoctonia inoculum at sowing

Rhizoctonia exists as a hyphal network, mostly in the top 2.5cm of soil, but can extend down to 10cm during the growing season. The fungus is adapted to dry conditions; which is probably why levels are highest in the top 2.5cm and why it is a serious problem in non-wetting soils.

The type of soil opener used affects the levels of rhizoctonia during seedling establishment. Inoculum levels along rows sown with knife points (high soil disturbance to 10cm) were much lower than those sown with a triple disc system with flat discs (minimum soil disturbance to 6cm). Inoculum levels in rippled coulter sown plots with disturbance to 10cm were intermediate (see Figure 2). High rhizoctonia levels in plots sown using the flat disc confirms that rhizoctonia is more serious with disc sown crops.

Early research results show coded fungicides applied in furrow can overcome much of the vulnerability of disc systems to rhizoctonia and enhance yields with knife-points. Ongoing work aims to optimise placement to improve reliability of control.

Rhizoctonia solani AG8 autumn 2008 and 2009



Rhizoctonia solani AG8 levels autumn 2011

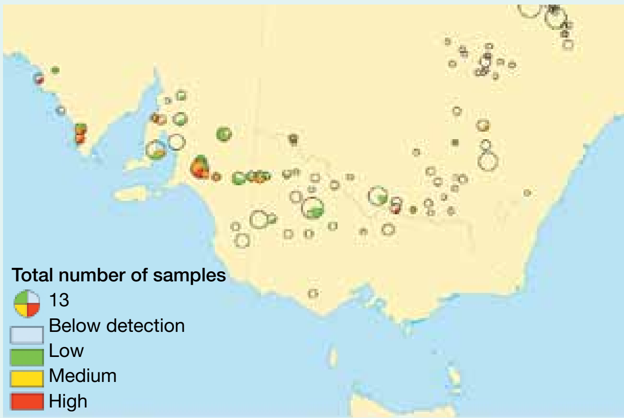


FIGURE 1a 2008 and 2009; both years were preceded by drought and dry summer

FIGURE 1b Autumn 2011; followed a good growing season and wet summer

Impact of rotations

While rhizoctonia can attack a wide range of plants and grow on plant residues in soil, it is now clear the main hosts are cereals and other grasses. Inoculum levels also increase throughout the growing season particularly during spring and reach maximum levels as the crop dries off (see Figure 3).

Grass-free canola, mustards and medic pastures provide useful reductions in inoculum, which can benefit the following wheat crop, increasing yields between 9% and 47%. However the reduction in inoculum lasts for only one season as rhizoctonia builds up on the roots of the wheat during spring. This can be seen by examining the crown roots for spear tips.

Rotation impacts were confirmed in field trials at Streaky Bay (Eyre Peninsula, SA), Waikerie and Karoonda (Murray Mallee, SA) and Galong, New South Wales over several seasons. Current research is investigating the effect of a broader range of rotation options.

Summer autumn rainfall

Inoculum levels are reduced by summer rainfall (see Figure 3).

- Inoculum remains high when there is low or infrequent summer/autumn rainfall.

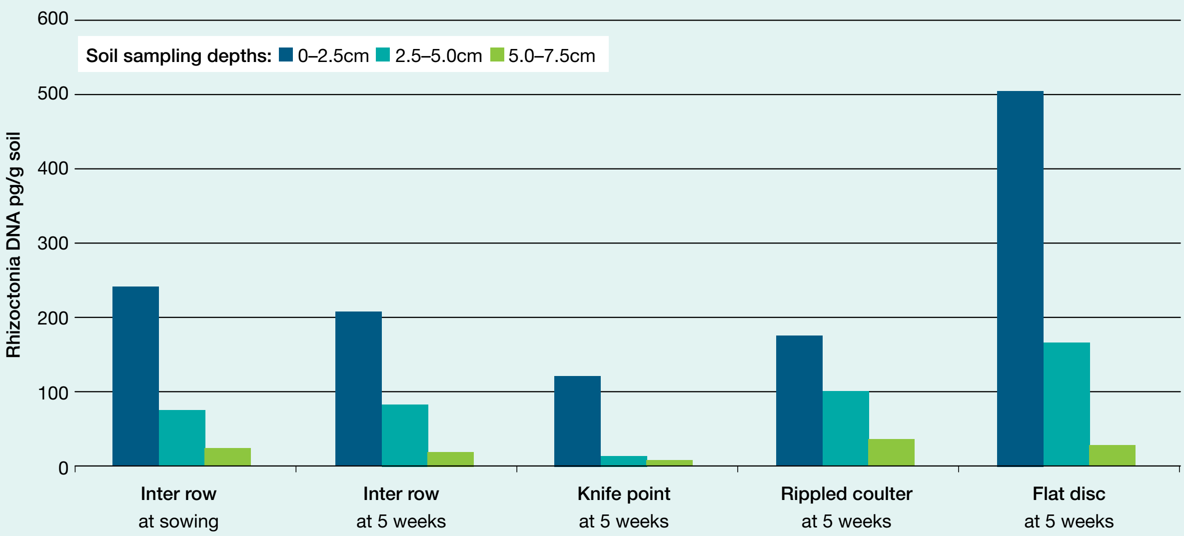
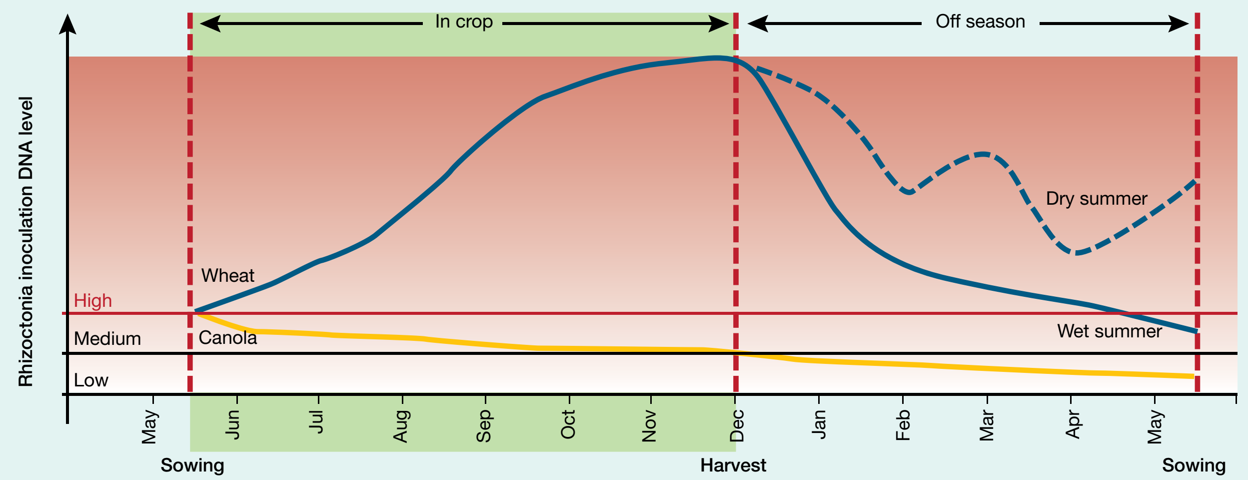


FIGURE 2 Rhizoctonia DNA levels in undisturbed soil and rows sown with knife point, rippled coulter and disc systems in 2.5cm layers down soil profile at sowing and five weeks after sowing at Geranium SA 2010 ($P<0.05$)



Wet summer = multiple rainfall events throughout summer; Dry summer = long dry periods (~4 weeks) between rainfall events.
Note that wet summer can reduce inoculum risk from high to medium.

FIGURE 3 Impact of crop rotation and summer rainfall on changes in rhizoctonia inoculum levels throughout the year

- If a significant summer rain event is followed by a prolonged dry period allowing the soil to dry out, rhizoctonia levels initially decline but then increase as the fungus regains a competitive advantage over other soil biota to grow saprophytically on plant residues.
- Repeated significant summer rainfall events that result in the soil remaining moist cause rhizoctonia to decline to low risk levels irrespective of rotation. Retaining stubble cover and controlling weeds will conserve moisture and maximise inoculum decline. Summer weeds can also be hosts.

The impact of summer rainfall can be seen in the rhizoctonia levels detected by PreDicta B in grower samples submitted for testing before sowing during 2008, 2009 and 2011. The first two years followed droughts and had dry summers and high rhizoctonia levels (see Figure 1a). The 2010–11 summer had a high incidence of summer rainfall and relatively low rhizoctonia levels pre-sowing (see Figure 1b).

Impact on crop growth

Rhizoctonia can attack crop roots throughout the growing season. Severe damage to seedling roots results in the characteristic bare patches. However in many early sown crops, root damage is delayed until around tillering and causes uneven growth.

Seedling damage can be minimised in many paddocks by sowing early and reducing any constraints to root growth, such as nutrient deficiencies (especially nitrogen) or compaction layers. However, as soil temperature drops to about 10°C, root growth slows and the fungus can attack crown and seminal roots. Ensuring adequate nitrogen and micro-nutrients during tillering will help reduce such losses. In future, new fungicide options are expected to provide additional control.

Damage to the crown roots continues throughout spring and can result in reduced tiller number per plant and yield. This symptom of the disease has not generally been attributed to rhizoctonia, so yield losses associated with it are not included in current costs.

Identifying high risk paddocks with PreDicta B

The current PreDicta B risk categories give an accurate guide to disease risk in most areas. However, disease severity depends on a combination of factors including soil disturbance and nitrogen levels at sowing, constraints to root growth (compaction layers, low temperatures, soil moisture) and activity of the soil biology community.

Regional differences in disease risk can occur. In particular, on the western slopes of southern NSW where there is significant summer rainfall followed by long cold winters, even very low rhizoctonia levels at seeding can cause significant disease. In this region it would be better to collect soil samples as soon as practical after harvest, before summer rainfall can significantly reduce inoculum levels. This will make it much easier to identify potentially high risk paddocks. In most other cropping regions sampling time appears less critical.



Future work

Ongoing research will:

- further our understanding of the role of summer weeds and rotation crops
- develop techniques to band fungicides to improve disease control
- fast track evaluation and registration of new fungicides
- develop more reliable disease prediction based on rhizoctonia inoculum levels and possibly tests for microbial community structure that modify disease risk.

Further reading

- GRDC Factsheet March 2012 **http://www.grdc.com.au/uploads/documents/GRDC_FS_rhizo.pdf**

SPONSORS

GRDC, SAGIT and Syngenta.

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Getting on top of fleabane and windmill grass

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Key points

- Windmill grass and fleabane have been confirmed as glyphosate resistant.
- Both species are becoming problematic weeds in no-till crops and summer fallows.
- Using the 'double knock' herbicide method is the key to successful weed control in fallows, however applying this tactic is expensive and requires attention to detail.
- An integrated weed management approach is required for best long-term management of windmill grass and fleabane.
- A range of herbicides is available with effective residual fleabane activity that can be used in fallow or in winter crop.
- A new WeedSeeker® permit will enable improved control options for these weeds in fallows (NSW only) and could make double knocking more affordable.

Background

Windmill grass (WG) and flaxleaf fleabane have become major weeds of cropping in many parts of Australia. They can be difficult to control and are thought to have increased for several reasons:

- Increased adoption of no-till farming.
- Heavy reliance on glyphosate for fallow weed control.
- The development of glyphosate resistance in both species.
- Before 2000 neither species was considered a problem weed and were not adequately controlled.

Both weeds can greatly reduce stored water supplies during fallows and compete aggressively in thin crops, reducing yields. Their seeds spread by wind and seeds of both species are considered surface germinating. Peak emergence of seedlings is commonly reported after mild wet springs and autumns. Fleabane and WG have limited registered herbicides for control, and there appears to be more unregistered options than registered ones. This is a challenge for industry, regulators, growers, chemical registrants and researchers.

Although these weeds have many similarities there are some subtle differences:

- Researchers have developed effective fallow, in-crop and fenceline options for fleabane control as a result of nearly 10 years of investigation. Fewer control options for WG exist due to much less research done on this weed and probably fewer viable options for research.
- Fleabane is an annual weed and WG can be annual to perennial, making WG more persistent.
- Chemical control options differ for the two weeds as one is a grass and the other a broadleaf.
- Many ecological studies have been done on fleabane but not on WG.

An integrated weed management (IWM) strategy incorporating chemical and non-chemical tactics, such as crop competition, for controlling seedlings and preventing seed production on survivors will result in substantially fewer problems and a reduced risk of herbicide resistance in fleabane and WG.

Life cycle and management implications

Knowledge of the life cycle of a weed helps to better target weed management practices for improved weed control. The germination of both species is largely light and temperature dependant with more weed seedlings emerging in paddocks with crop stubble and sections of paddocks that enable longer periods of moisture. Monitoring for new emergences is important, as it is much easier to control young fleabane and WG plants. Fleabane seedlings will only emerge from the top 1cm of soil with similar emergence characteristics for WG, which partly explains why these weeds proliferate in no-till systems.

As both weeds can emerge during late autumn they are most likely to be a problem in winter crops and fallows. Pre-sowing, in-crop and after harvest control can be necessary. Both weeds are easily controlled when they are small and young. After elongation or multi-tillering begins, there are few effective herbicide options available.

Most fleabane seeds in the soil lose their viability within 12–18 months. However a small percentage can persist for several years with the quantity influenced by burial depth.

A pot study on the Darling Downs, Queensland showed that after three years of burial 1%, 10% and 8% of viable seed remained at depths of 0–2cm, 5cm and 10cm respectively. A tillage trial on the Darling Downs near Dalby found that the emergence of fleabane was generally reduced under tillage, but that a light harrow increased emergence possibly because of more seeds being exposed to light (see Figure 1). While seed burial through cultivation could be a possible option for fleabane control, it is important to realise that buried seeds can remain viable and be brought back to the soil surface by subsequent tillage events.

Controlling the problem

Current herbicide registrations for controlling WG and fleabane in summer fallows are limited to Touchdown Hi Tech (glyphosate 500g/L), Spray.Seed® and paraquat (e.g. Gramoxone), all of which are registered for most annual weeds. Fleabane is an annual weed while WG is occasionally referred to as an annual during dry seasons. There are two other selective products registered for control of each weed species in various situations (see Table 1).

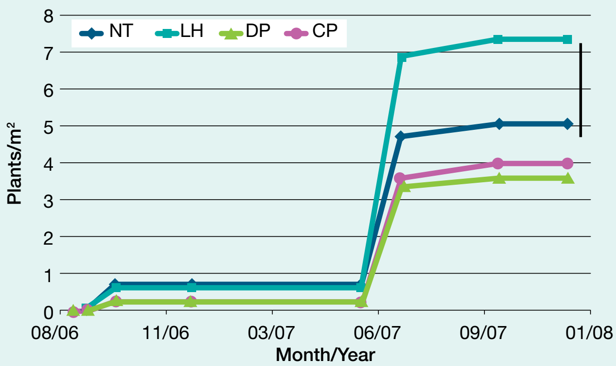
Crucial research findings

Windmill grass

The Grain Orana Alliance (GOA) has highlighted the importance of double knocking WG (see Figure 2).

Adding a double knock (+DK) to any of the treatments in Figure 2 significantly increases the level of control of the mature WG plants. Despite this none of the group M treatments, with the exception of the extreme rate (ER), have failed to reach acceptable control levels. Group A herbicides with double knocking treatments have also performed well, with several products actually achieving commercially acceptable control.

Also investigated was the effect of delayed application on herbicide efficacy. Three treatments were applied at four different timings. Two rates of Group M herbicide: high rate (HR) and very high rate (VHR) and a very high rate (VHR) of a Group A herbicide were applied to separate plots followed by a double knock seven days after the initial treatment (see Figure 3).



Source: Queensland DAFF

FIGURE 1 Cumulative emergence of fleabane seedlings following no soil disturbance (NT), tillage with light harrow (LH), disk plough (DP), or chisel plough (CP)

The results suggest that, regardless of the product choice, control drops off sharply between 11–18 days post rainfall. All group M herbicide treatments resulted in unsatisfactory levels of control. In the case of the VHR of the Group-A herbicide, the first two timings either exceed what was considered acceptable control or performed close to acceptable. However with increasing moisture stress and larger plants, control levels declined and became unacceptable.

Further research is planned to answer the following research questions:

- Can the good levels of efficacy of Group A herbicide be improved significantly?
- With greater detail, what is the link between moisture stress and herbicide efficacy?
- What is the optimal timing (growth stage and days between knocks) for a double knock?
- Can residual herbicide play a crucial role with WG management? Should they be used in combination with cultivation? Can in-crop WG be achieved?

TABLE 1 Registered herbicide for windmill grass (*Chloris* sp.) and fleabane control

Windmill grass		
Product name	**Active ingredient**	**Use situation**
Dacthal 900™	900g/L chlorthal-dimethyl	Various brassica and vegetable crops, cotton, lucerne and lawns
Factor™	250g/L butoxydim	Various summer crops (for example, mungbeans, cotton, sunflowers)
Fleabane		
Product name	**Active ingredient**	**Use situation**
Amicide Advance	700g/L 2,4-D amine	Various winter cereals and fallows
Tordon 75-D	300g/L 2,4-D amine + 75g/L picloram	Fallows prior to winter cereal
Alliance	250g/L amitrole + 125g/L paraquat	Fallows prior to winter crops

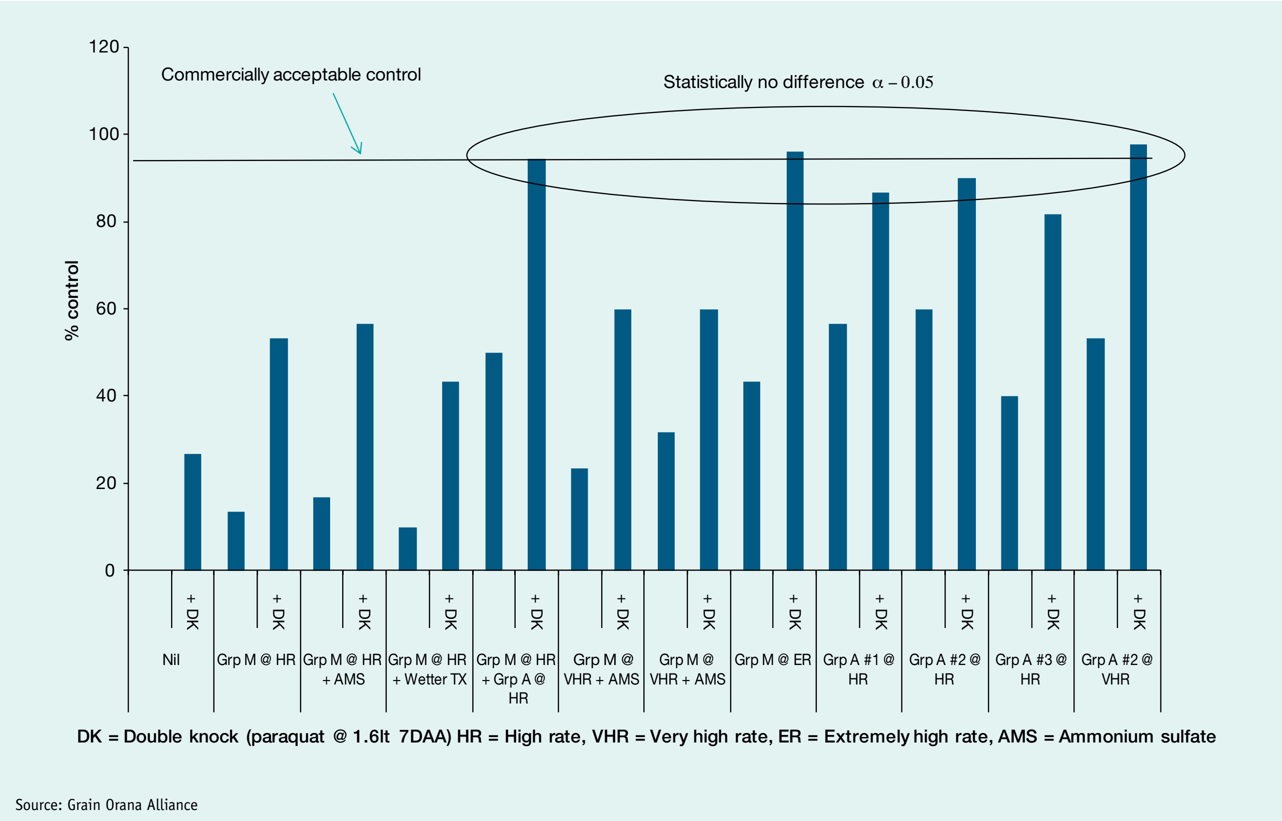


FIGURE 2 Control of mature windmill grass plants by various herbicide treatments at 49 DAA

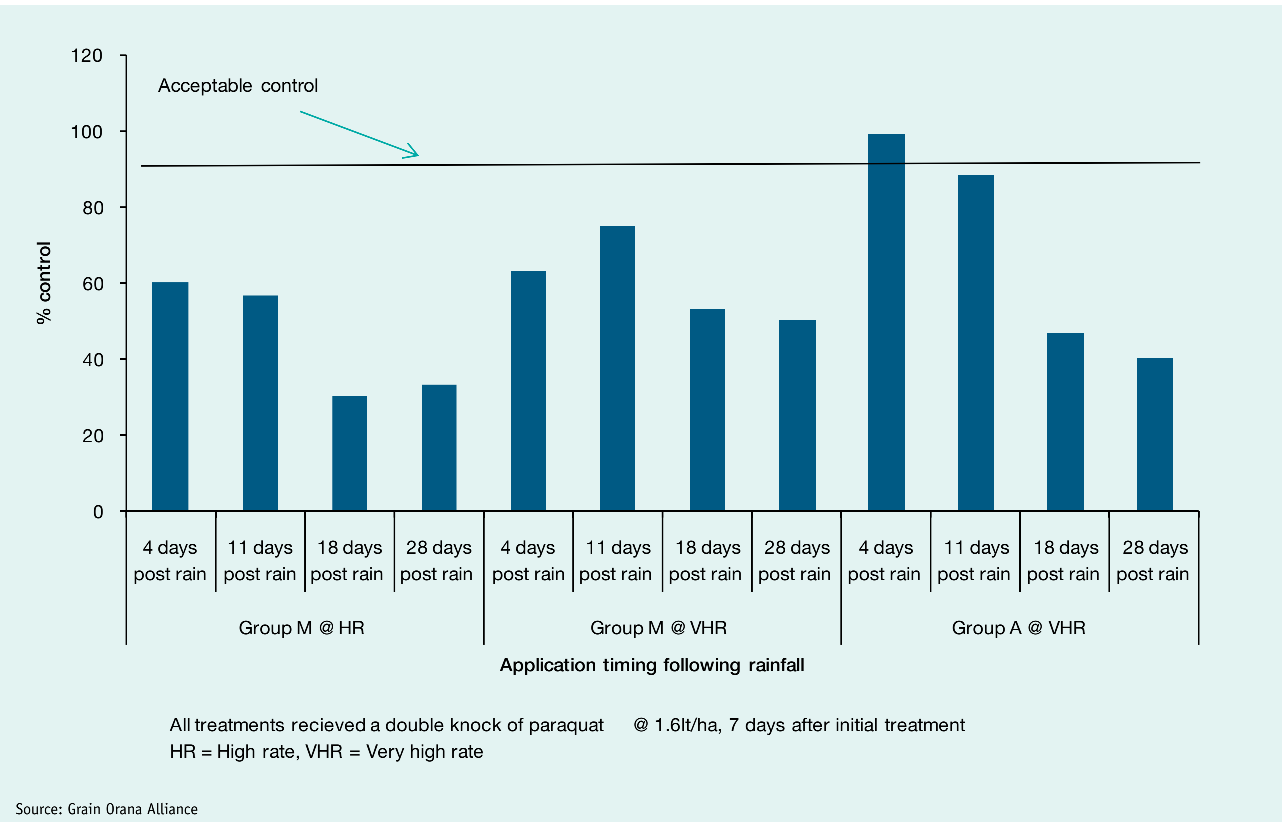


FIGURE 3 Mature windmill grass control in response to delayed herbicide application at 97 days after application

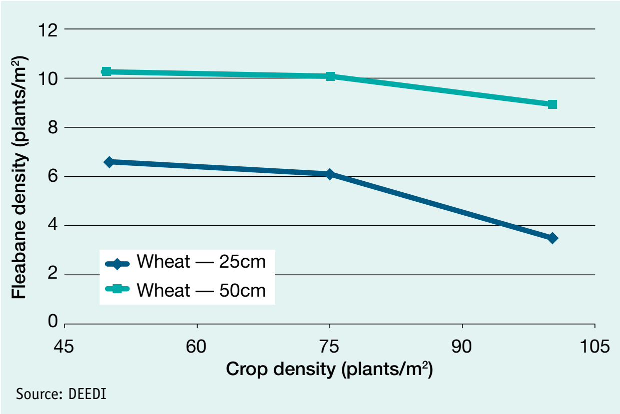


FIGURE 4 Fleabane density in wheat of different row spacings and plant densities

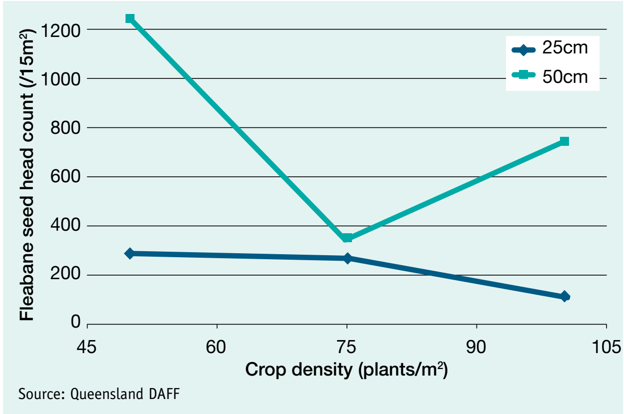


FIGURE 5 Average fleabane seed head counts in wheat, durum and barley across different row spacings and plant densities

Flaxleaf fleabane

Fleabane plant density and seed production can be substantially reduced using crop competition in the absence of herbicides. For wheat, fleabane numbers tended to decrease with increasing crop density and narrower row spacing (see Figure 4). On average, weed density decreased by 26% as crop population increased from 50 to 100 plants/m^2 and by 44% as row spacing decreased from 50cm to 25cm.

These treatments also impacted seed production, as indicated by seed head counts (see Figure 5). Row spacing tended to have a much larger effect than crop density. An experiment at Trangie, New South Wales undertaken by district agronomist Rohan Brill reported similar results. The 2011 experiment showed that a 66cm row spacing resulted in 120% more fleabane in fallow than the 33cm row spacing. The data indicated that durum wheat responded very similarly to bread wheat.

In-crop herbicides

Amicide Advance® is the only in-crop (cereal) option registered for fleabane control. However, other herbicides commonly used in-crop can be effective on young fleabane.

In a 2010 trial near Warwick, Queensland in-crop herbicides were applied in wheat at two different times, two weeks apart. At the first spray most fleabane plants were small (<5cm) and at the latter spray there were more plants that were >10cm. The results (see Table 2) show that a range of treatments provided >85% control when applied to young fleabane. Delaying application by two weeks resulted in an

TABLE 2 Fleabane biomass reduction four weeks after in-crop herbicide treatment applied two weeks apart

Herbicide	Biomass reduction (%) four weeks after treatment	
	First time of spraying	Second time of spraying (two weeks after first spray)
Untreated	0	0
Group B sulfonylurea	76	4
Group I phenoxy	98	91
Group I pyridine	95	0
Group I pyridine	85	6
Group I phenoxy	87	92
Group I phenoxy	77	44
Group B sulfonylurea + Group I phenoxy	86	35
Group I pyridine + Group I phenoxy	93	50
Group I pyridine + Group I phenoxy	77	57
Group I phenoxy + Group B sulfonylurea	84	73
Group I phenoxy + Group I phenoxy	86	28
MEAN	86	44

Specifics of rate and product have been deleted from the above table as none of the herbicides listed are registered for the control of fleabane.

average 40% reduction in control. The Group I phenoxy herbicides provided the greatest control of both young and older fleabane.

No treatment provided 100% control of fleabane and there were new flushes of emergence after herbicide application. Products containing picloram (for example, Tordon) reduced subsequent emergence by more than 50%.

Many researchers have found that sulfonyl-urea herbicides are of moderate benefit in controlling fleabane. These herbicides can play a role as a pre-emergent or early post-emergent. If applied as a post-emergent they should be mixed with a Group I herbicide. There is also evidence that Group H chemistry could provide an effective mode of action for fleabane control and be used as a herbicide rotation option. None of the treatments listed in Table 2 are suitable for winter cereal undersown with lucerne. However, in an experiment investigating lucerne compatible fleabane treatments in wheat (data not presented) a Group I and Group C herbicide were found to be effective when applied to weeds less than 5mm in diameter.

Fallow herbicides

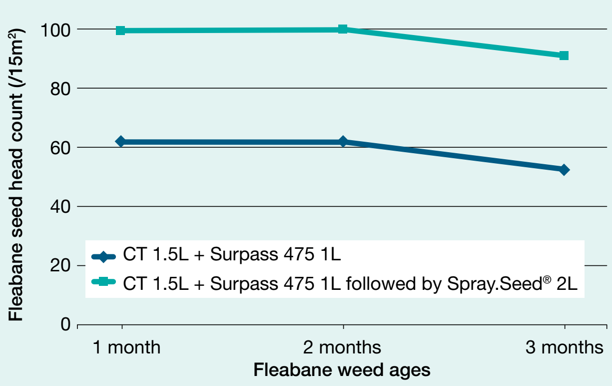
Fallow management of fleabane with a single herbicide application has been extremely inconsistent. Although effective control has been obtained with specific treatments in some situations, no consistent and robust option has been identified to cover a wide range of situations. This is typified by the research of Hillston, NSW district agronomist Barry Haskins who found the best three 'single-pass' treatments only provided between 90–95% control, which is inadequate as fleabane can easily replenish its seed bank from a small amount of residual seed. As a result the industry has needed to look at more involved (and much more expensive) techniques such as double-knocks but also is now seriously looking at the fit and value of residual herbicides in an overall weed management program.

1. Double-knock approaches

The most consistent and widely adopted double-knock for fleabane is a mix of glyphosate and 2,4-D as the first application, or knock, followed by a paraquat or paraquat and diquat based option as the second knock.

Figure 6 shows the value of the second knock. This trial was established to compare the effectiveness of double-knocks on fleabane at different ages. Fleabane was sprayed at about one, two or three months old. Including a second knock of Spray.Seed® resulted in excellent levels of control of fleabane at the two earlier stages. However at three months old, the double-knock approach resulted in only 90% control.

An additional range of single and double-knock treatments were evaluated for fallow control of fleabane across Queensland and NSW. The evaluations took place during 2009 and 2010 and examined the impact of fleabane age on herbicide efficacy. Results indicated that the double-knock approach is more consistently reliable than single knock treatments, across seasons



Source: Queensland DAFF 2009

FIGURE 6 Benefit of double-knock over single herbicide applications for fleabane control with knocks seven days apart

TABLE 3 Fleabane visual biomass reduction (% of untreated) 42 days after knockdown treatment across seasons (2009 and 2010) and Queensland and NSW

Herbicide (first knock followed by second knock)*	Rate	2009^		2010#	
		1 month	3 months	1 month	3 months*
Gly CT + Surpass 300	1.5L + 1.5L	62	53	88	83
Gly CT + Tordon 75D	1.5L + 0.7L	90	45	92	98
Gly CT + Surpass 300 fb Spray.Seed®	1.5L + 1.5L fb 2.0L	99	90	94	95
Gly CT + Tordon 75D fb Spray.Seed®	1.5L + 0.7L fb 2.0L	99	93	99	99
Gly CT + Surpass 300 fb Alliance	1.5L + 1.5L fb 2.0L	98	78	94	93
Amicide 625 fb Spray.Seed®	1.5L fb 2.0L	99	72	97	96

* = second knock seven days after first knock
^ = Queensland data only
# = averaged for Queensland and NSW

Source: Queensland DAFF and NSW DPI

and especially on older fleabane (see Table 3). When applied to older fleabane, the efficacy of the double-knock treatment is reduced (see 2009 data). To maintain the efficacy of the double-knock treatment on larger fleabane, the rate of herbicide applied needs to be increased (see 2010 data — age three months). The 2010 results have been averaged across Queensland and NSW as they did not differ significantly.

2. **Residual approaches**

   The difficulties and expense of controlling fleabane with knockdown sprays, together with early indications of glyphosate resistance in some summer grasses has generated interest in the use of residual herbicides as part of an overall weed management strategy.

   Where do residuals fit?

   To get the most benefit out of residual herbicides apply them **before the largest expected emergence flushes**. There are three key positions where residuals could be of benefit for managing fleabane:

   a) Use of a residual in autumn–winter during the winter fallow.

   b) Use of a pre-sowing or in-crop residual within the winter cropping program.

   c) Use of a pre-sowing or in-crop residual within the summer cropping program.

   During the winter of 2009, Queensland DAFF researchers applied a range of residual herbicides for fleabane control including:

   - Group B sulfonyl ureas (for example, Glean®)
   - Group B imidazolinones (for example, Flame)
   - Group C substituted ureas (for example, diuron)
   - Group C triazines (for example, atrazine)
   - Group H isoxazoles (for example, Balance®)
   - Group I phenoxy and pyridine mixtures (for example, Tordon® 75-D)
   - Group K chloroacetamide (for example, Dual® Gold)

   Figure 7 shows the cumulative control obtained from each treatment over a five-month period following application. Effective levels of residual control were obtained from all products with only the Group I phenoxy and pyridine mixture herbicide providing less than 90% control in the bare fallow.

   Specifics of rate and product have been deleted from Figure 7 as none of the herbicides listed are registered for the control of fleabane.

   Northern Grower Alliance (NGA) established four trials during winter 2009 to examine the effectiveness of a range of common residual herbicides. All were applied in a non-crop situation to investigate the relative efficacy of different active ingredients.

   All trials were established in a clean fallow between 25 June and 6 July with only low rainfall received during July, August and September. Fleabane residual control was assessed 32–72 days after application. Fleabane pressure was low in all trials. The results in Figure 8 show the average level of control of some of the key herbicides over the four trials.

   Specifics of rate and product have been deleted from Figure 8 as none of the herbicides listed are registered for the control of fleabane.

Main findings

1. Effective levels of fleabane control were obtained across all four trials from a high rate of Group C-substituted urea herbicide, a common in-crop rate of Group C triazine herbicide, a common in-crop rate of a Group H

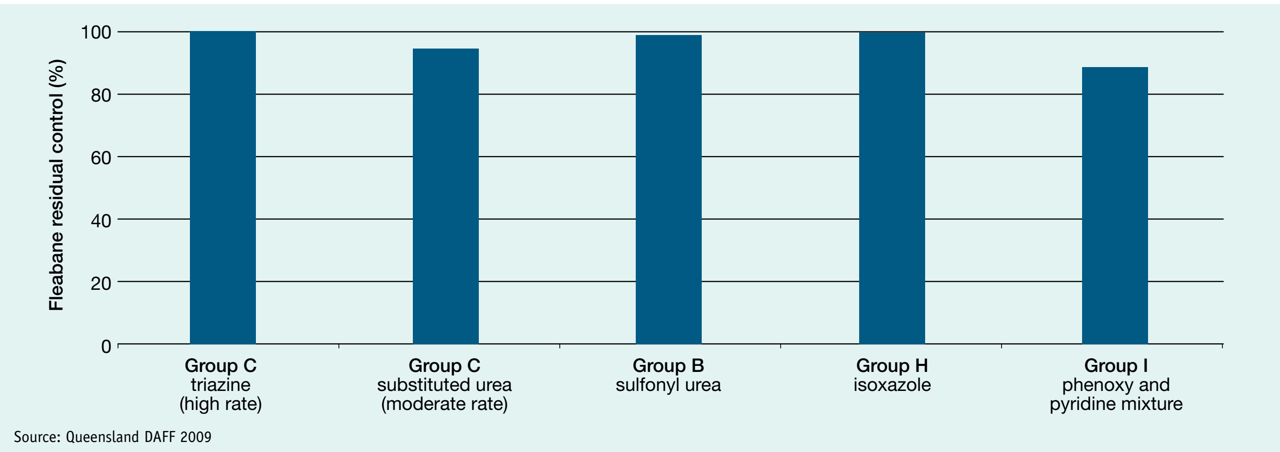
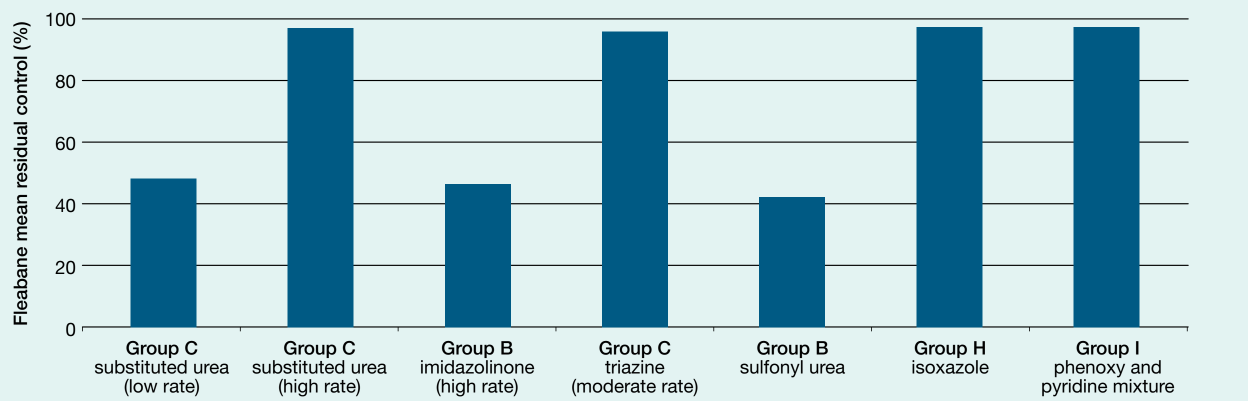


FIGURE 7 Residual fleabane control in winter fallow following double knock application



Source: NGA 2009

FIGURE 8 Residual fleabane control in winter fallow

isoxazole and a common in-crop rate of a mix of Group I phenoxy and pyridine herbicides. It is important to note that some of these products are only registered in-crop but can still be useful residual weed control tools.

2. No other option exceeded 90% control in any trial.
3. A label rate of a commonly used Group B sulfonyl-urea provided useful suppression in two trials (~80–85% control) but negligible activity at the other two sites (note: there was no crop competition in these trials).

Field trials using residual products during 2009 and 2010 in Queensland and northern NSW confirmed that the Group C substituted urea product provided consistently greater than 90% control of new flushes of fleabane emergence for at least six months after treatment.

Residual summary

Several herbicides provide effective residual activity against fleabane including:

- High fallow rates of Group C triazines for residual weed control applied in the autumn, before a rain event when sorghum is to be sown in the spring, or during early spring before planting the sorghum crop.
- A Group C substituted urea herbicide used in association with cotton or chickpeas.
- A group H isoxazoles in chickpeas.
- A Group B sulfonyl urea as a pre-sowing application to a winter cereal, particularly when combined with strong crop competition.
- A Group I phenoxy and pyridine mixture in fallow at least two months before winter cereals as part of a double-knock scenario to assist both knockdown control and provide useful residual control. Products containing the active picloram (for example, Tordon 75-D, Tordon 242) could also be useful in-crop tools when combined with strong crop competition.

Herbicide resistance — potential threats

Windmill grass

If the current recommendation to use Group A herbicides followed by a bipyridyl is used extensively there are clear risks of developing Group A and/or L resistance. This is likely to present itself within five to 10 years, as shown in other case studies (management of glyphosate resistant annual ryegrass developed Group A resistance). The need to incorporate cultivation with residual herbicides is therefore paramount.

Fleabane

Although there appears to be more chemical strategies to combat this weed, most rely upon Group I herbicides. Some selection pressure will be on Group L via the use of double knocking. To be proactive in managing resistance, development and promotion of alternative mode of action (MOA) herbicides is required (for example, Groups C and H).

A new technology that has a good fit (WeedSeeker®)

The APVMA have just issued a permit that enables NSW growers access to a wider range of herbicides and rates in fallow when using a WeedSeeker®.

Thirty different herbicides are listed on the permit from seven MOA herbicides, some being non-residual and others with shorter-term or longer-term activity in the soil. This offers great flexibility for those managing difficult to control fallow weeds, such as fleabane and windmill grass.

Some herbicide rates have been increased to allow control of larger, stressed or harder to control weeds. For example, the glyphosate 450 rates range from 3–4L/ha, which far exceeds the label blanket rate of 400mL to 2.4L/ha. Likewise, similar increases in rate are allowed for paraquat or Spray.Seed®.



Not only is this technology useful for controlling small or scattered light weed patches in fallows, it can be used to effectively manage glyphosate-resistant weeds. As stated previously, herbicides such as paraquat or Group A herbicides are extremely useful options to control windmill grass. The new permit will allow the use of these herbicides at robust rates.

The key to successful resistance management is killing the last few individuals. This becomes difficult on large-scale properties. Much time is spent scouting for these small patches and if not controlled will result in significant seed production and re-setting of the weed seed bank. The WeedSeeker® will make the final stages of an eradication campaign more feasible.

Applying Group A herbicides in fallows is widely accepted by many as a risky practice because it selects for Group A resistant species. Appropriate warnings are listed on the permit to prevent the onset of Group-A resistant weeds in fallows. For most situations a follow-up spray with paraquat or Spray.Seed® prevents any survivors producing seed. If all else fails cultivation must be used to ensure survivors do not set seed.

Summary

Windmill grass

Windmill grass has emerged recently as a major threat to no-till systems in which herbicides are the only weed control method. The use of less effective herbicides has seen the weed infest paddocks at an ever-increasing rate and the recent identification of glyphosate resistance adds further to the difficulties of its control.

Research into this problem has been limited with some conflicting data. Common outcomes are:

- Final control is related to moisture availability before, during and after spraying.
- Double-knock treatments can increase effectiveness.
- Group A herbicides appear promising for control but are unregistered for such use patterns.

The recent identification of glyphosate resistance in WG has seen the weed attracting the attention of groups such as the Australian Glyphosate Sustainability Working group and research institutions like Queensland DAFF and NSW DPI.

Windmill grass has recently been identified to GRDC as one of the five major weeds in the northern cropping region. As such, we will see an increased focus on developing our understanding and controlling this problem weed both locally and from a national perspective.


Photo: Tony Cook

Fleabane

Successful control of fleabane and other weeds will only be achieved by using a combination of management tools. Clearly there are economic and management downsides to using double-knocks or residual herbicides and registrations for these practices and potential WG treatments are needed. Double-knocks and residual herbicides provide the most robust options to manage this widespread weed. Hopefully the arrival of new products will provide additional effective tools.

One key lesson learnt in fleabane herbicide management is to move the main battle from late spring and summer (when weeds have hardened off and are difficult to completely control) to earlier in the season. This way we can use either effective double-knocks on smaller weed stages or incorporate residual chemistry into our fallow or in-crop management on a paddock-by-paddock basis.

When effective control of both weed species is achieved, maintaining excellent levels of control requires patch management of small infestations, keeping non-cropping areas clean and having a focus on preventing weed seed production.

Disclaimer

Please note, some of the herbicides mentioned in this paper are only registered for 'in-crop' use and some do NOT have recommendations for the control of fleabane. **Always read and follow label directions**.

ACKNOWLEDGEMENTS

Thanks to the many growers and consultants involved in this trial work, together with Clare Felton-Taylor and Anthony Mitchell for NGA field activity. Thanks also to Barry Haskins and Rohan Brill from NSW DPI for their additional research into fleabane management. The research reported on in this paper falls under the GRDC codes DAQ000137, UQ00062 and GOA00001.

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Cover cropping — does it pay?

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[1] EH Graham Centre for Agricultural Innovation (an alliance between NSW Department of Primary Industries and Charles Sturt University)

[2] CSIRO Sustainable Agriculture Flagship

[3] CRC for Future Farm Industries

Key points

- Cover cropping reduces pasture production during following years.
- Grain yields can provide substantial income to compensate for lower pasture production.
- A new decision support tool helps growers determine whether establishing pastures by cover cropping is the most profitable option.

Aim

Pastures in the cropping zone are usually established by sowing the pasture species under a cover crop, despite this practice sometimes leading to a higher rate of failure and less productive pastures. However most growers establish pastures via cover cropping because the grain yield generated from the crop covers the cost of sowing the pasture.

To date, most research has focused on pasture density and biomass production of different establishment methods but has not demonstrated the increased livestock productivity needed to offset any income from grain production. The decision support tool outlined in this paper quantifies the costs and incomes for the pasture phase to help growers with pasture establishment decisions.

Method

Two field experiments were carried out at Brocklesby during 2009 and 2010 with both experiments sown by the co-operating farmer in a paddock that was to be sown to pasture. Treatments included different cover crop rates and pasture species across sites and seasons (see Table 1). Sites were assessed in the establishment year and the following year to determine plant density and pasture production. Results in this paper focus primarily on the perennial component of the pasture mix. Rainfall at Brocklesby was below long-term average during 2009 and above average during 2010.

Using the decision support tool

Field experiment results were analysed using the decision support tool to determine if cover cropping was the optimal method for pasture establishment. The decision support tool has been created with MS Excel with a user-friendly display into which users input their own data and choose sensitivity graphs as desired. The inputs in the decision support tool include expected grain yield, grain price, stocking rate and stock earnings, establishment costs, the length of the pasture phase and relative effect that cover cropping has on pasture production.

The underlying calculation for the decision support tool is the net income from the cover cropped (CC) pasture establishment method minus the net income from straight sowing (SS) the pasture for the length of the pasture phase.

(Grain income + CC stock income – CC variable cost) – (SS stock income – SS variable cost)

Where:

Grain income	= grain yield × grain price
CC stock income	= stocking rate × \$/DSE × (pasture years - 1) × CC relative effect
SS stock income	= stocking rate × \$/DSE × (pasture years - 1)
CC variable cost	= cost of establishing grain crop and pasture under a cover crop
SS variable cost	= cost of establishing straight sown pasture

TABLE 1 Cover crop and pasture treatments imposed at the Brocklesby sites during 2009 and 2010

Site	Year	Cover crop	Cover crop rates (kg/ha)	Pasture species and rates	Rainfall (mm)
Brocklesby	2009	Barley	0 and 60	Lucerne (4kg/ha) and subclover (4kg/ha)	409
Brocklesby	2010	Barley	0, 22.5 and 45	Lucerne (4kg/ha), subclover (2kg/ha), arrowleaf clover (2kg/ha) and chicory (0.5kg/ha)	855

The value for $/DSE was determined from NSW DPI farm budgets and represents the net income from livestock, including costs for stock and pasture management. The years are for the length of the intended pasture phase minus the establishment year where grazing is limited. The decision support tool does not calculate pasture production *per se* but rather calculates differences in stocking rates, which presumably are related to pasture production.

The decision support tool provides a single number to estimate the most profitable pasture establishment method. If the returned value is positive then more profitability is obtained from cover cropping. In contrast if the value is negative, directly sowing the pasture would be more profitable. A series of sensitivity analyses are built into the decision support tool to provide paired comparison between factors of interest to the user.

TABLE 2 Input data for the decision support tool used in the Brocklesby experiments and established 'rules of thumb' for cover cropping

Input	Brocklesby	'Rules of thumb'
Grain price ($/t)	150	150
Grain yield (t/ha)		2.5
Stocking rate (DSE/ha)	12	10
$/DSE	25	25
Pasture establishment cost		
Cover cropping (CC) ($/ha)	200	200
Straight sowing (SS) ($/ha)	120	120
Years for pasture phase	4	4
Cover cropping relative effect (0–1)	Reduced pasture production due to cover cropping	0.6

Rules of thumb for cover cropping

A simulation study using the decision support tool was done to determine whether any 'rules of thumb' could be established for cover cropping. The parameters used in the decision support tool are presented in Table 2. Sensitivity analysis was done for a range of parameters including grain yield, length of the pasture phase, the relative value of cover cropping and stock gross margin ($/DSE).

Results

There was no difference in plant density during 2009 following pasture establishment by cover cropping however cover cropping reduced biomass production during the following wet year of 2010. During 2010 cover cropping did not reduce plant density of lucerne or chicory but in the following year lucerne dry matter (DM) was reduced at both cover crop rates (see Table 3).

Results of the field experiments were analysed using the decision support tool to determine the most profitable method of sowing pasture. High grain yields from the cover crop resulted in the cover cropping treatment achieving higher total gross margins than direct pasture establishment (see Table 4).

The decision support tool enables the user to examine the sensitivity of each of the parameters and develop some 'rules of thumb' in regards to cover cropping. Using the basic parameters from the simulation study, cover cropping was more profitable when grain yields exceeded 2.5 t/ha (see Figure 1a). If the pasture phase lasted longer than four years, directly sowing the pasture was more profitable. Cover cropping was more profitable when the CC relative value was more than 0.6. Direct sowing pasture was more profitable when stock incomes exceeded $25/DSE.

TABLE 3 Plant density and total dry matter for the year following pasture establishment at Brocklesby

Brocklesby 2009		Cover crop rate			
		0kg/ha	60kg/ha		
Plants/m²	Lucerne	27	21		ns
2010 DM (kg/ha)	Lucerne	20195a	15066b		P < 0.05
	Total DM	**23529a**	**18034b**		**P < 0.05**
Brocklesby 2010		**Cover crop rate**			
		0kg/ha	22.5kg/ha	45kg/ha	
Plants/m² (Dec 2010)	Lucerne	34	31	32	ns
	Chicory	7	9	7	ns
2011 DM (kg/ha)	Lucerne	4647a	2252b	3053a,b	P < 0.05
	Chicory	3965a	4256a	3354b	P < 0.05
	Total DM	**10266a**	**9250b**	**8885b**	**P < 0.05**

TABLE 4 Decision support tool analysis of the field experiments at Brocklesby during 2009 and 2010*

Year	Grain yield (t/ha)	CC relative effect	Difference in total gross margin ($/ha)
2009	4.0	0.77	313
2010	3.8	0.90	400

* Total gross margin is the difference between pasture established under a cover crop and a pasture established directly.

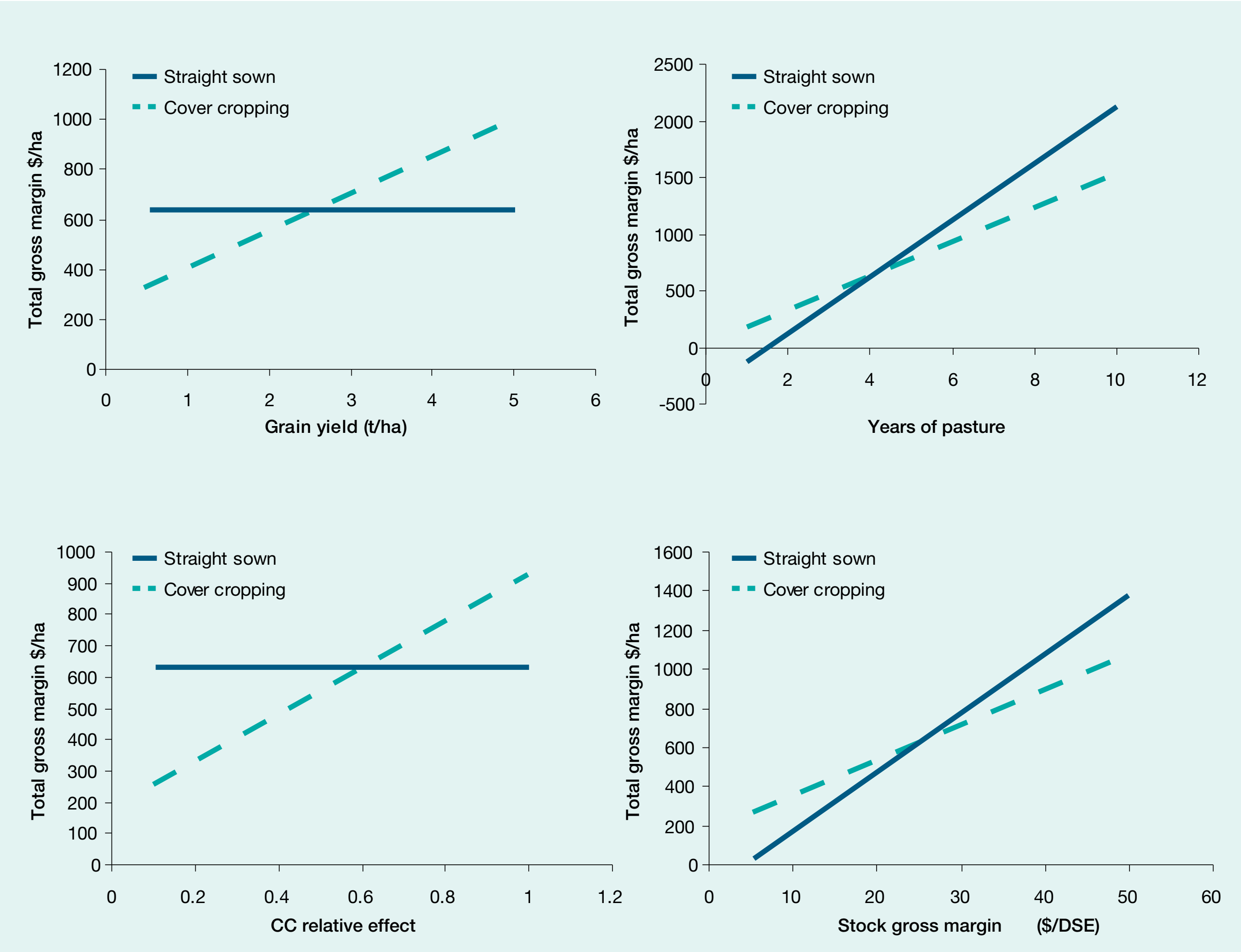

FIGURE 1 Sensitivity graphs for the decision support tool simulation study for the effect on a) grain yield b) length of pasture phase, c) cover cropping relative effect and d) stock gross margin

Photo: Catriona Nicholls

Observations and comments

In wetter conditions pasture plant establishment numbers were similar between the cover cropping and direct sowing methods. Yet, despite similar plant densities a negative effect of cover-cropping, in terms of pasture productivity, was still observed.

The primary purpose of pastures on farms is to increase the long-term profitability of the farming system. Although the field experiments demonstrated a loss of pasture production in more favourable seasons, the decision support tool demonstrated it was difficult for animal production systems to use the extra pasture produced and cover the cost of not producing grain in the establishment year.

Under higher rainfall conditions, pastures established using cover cropping produced less DM. Using the decision support tool demonstrated that cover crop yields higher than 2.5t/ha generated higher profits than pasture established under a cover crop. Higher stock income and longer pasture phases resulted in directly established pasture being more profitable.

SPONSORS

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Does wheat variety influence grain protein?

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[2] NSW DPI Condobolin, Coonamble and Tamworth

Key points

- Grain protein is determined by the balance between the nitrogen requirement of a crop and the supply of nitrogen to that crop, as well as by environmental conditions during grain filling. Yield and grain protein concentration are often negatively correlated.
- Nitrogen nutrition is the major management tool growers can use to alter grain protein; variety choice plays a relatively minor role.
- The reportedly lower grain protein concentration of EGA Gregory$^{\phi}$ is primarily a result of high yield and a resultant dilution of protein. Gregory$^{\phi}$ appears to be within 0.8 percentage units of most other varieties at comparable yield levels.
- Initial results indicate that LongReach Spitfire$^{\phi}$ may have a higher grain protein concentration at a given yield level relative to other wheat varieties.
- In choosing a variety, growers are advised take these factors into account in conjunction with disease ratings, maturity group, yield performance and quality premiums.

Background

Grain protein was a crucial issue for growers during the past two seasons. For the 2011 harvest, there were large premiums (up to $80/tonne) paid for AH and APH grades over ASW and APW. The loss of payments for protein increments within grades (the old 'Golden Rewards') and the volatility of prices during harvest added further complications. While the premiums for these grades are not guaranteed, they have encouraged growers in central and southern NSW to select varieties acceptable for these grades. There has also been considerable discussion among growers and agronomists as to whether some varieties achieve higher grain protein than others when grown under the same conditions.

Nitrogen nutrition and grain protein

Grain protein is determined by the balance between the nitrogen requirement of a crop and the supply of nitrogen to that crop, as well as by environmental conditions during grain filling. The nitrogen requirement of a crop is set by the water-limited yield (stored moisture plus in-crop rainfall), the crop species (for example, wheat, barley, canola), the desired grain protein and, crop management (disease, phosphorus supply, weed control and sowing time).

The nitrogen supply for crops in the lower rainfall areas comes mainly from decomposing organic matter and this is controlled by the amount of organic matter, the quality of the organic matter (carbon to nitrogen ratio, particle size, age), soil type and suitable conditions of temperature and moisture for mineralisation. Fertiliser nitrogen usually accounts for a small proportion of total nitrogen supply but can still be crucial for achieving desired yield and protein targets.

Optimising nitrogen supply is difficult in western regions of eastern Australia given the highly variable seasons. Excessive application of nitrogen may increase water use early in the growing season leading to greater water stress during flowering and grain fill, resulting in poor grain set or shrivelled grain. Insufficient nitrogen may limit grain yield and grain protein, reducing profitability. Within a given season, fertiliser rate and timing are the major tactical tools used for nitrogen management. Applications of nitrogen at sowing or up to the start of stem elongation can increase crop biomass, grain number and grain yield whereas later applications (around anthesis or GS61) have little influence on grain yield but can drive a significant protein response.

Figure 1 outlines the time course of nitrogen uptake by a wheat crop at Condobolin, New South Wales. Early growth

consists predominantly of leaves and while these have a high nitrogen concentration the low dry matter (DM) at this stage means that the total requirement is low. Demand is greatest during stem elongation and ear emergence, a period of rapid DM production, during which about 60% of total uptake occurs. This explains why nitrogen fertiliser application during tillering can be particularly effective for yield, provided conditions are suitable for nitrogen uptake.

Much of the nitrogen converted into grain protein is taken up before flowering, stored in the leaves and stems and remobilised during grain filling. Protein synthesis continues in the grain throughout filling, the rate of nitrogen accumulation being almost linear (see Figure 2). Water stress or high temperatures during grain fill can result in high protein percentages because these conditions tend to reduce starch synthesis more than protein synthesis. In this example, the low-stress treatment took up sufficient nitrogen to achieve a grain protein level close to the stressed treatment.

As the rate of nitrogen supply is increased, yield will generally increase to a maximum level, whereas protein may continue to increase with further nitrogen application. This is demonstrated by the results from a trial at Parkes, NSW during 2011, sown as part of the GRDC-funded ‘Variety Specific Agronomy Packages’ project (see Figure 3). Wheat yield was responsive to nitrogen fertiliser but at a reducing rate where nitrogen was applied in 30kg/ha

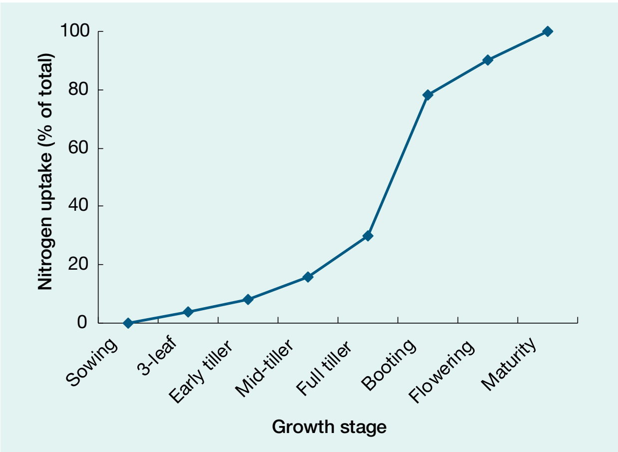

FIGURE 1 Relationship between growth stage and accumulated uptake of nitrogen by a wheat crop, expressed as a percentage of the total uptake

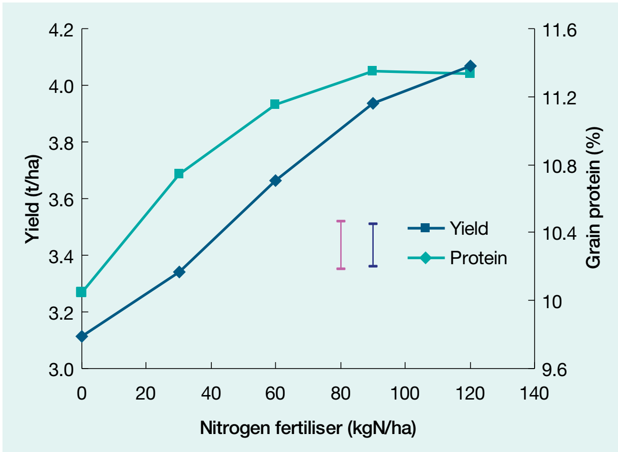

FIGURE 3 Grain yield and protein concentration for 10 wheat varieties with 0, 30, 60, 90 or 120kg/ha applied nitrogen, Parkes 2011

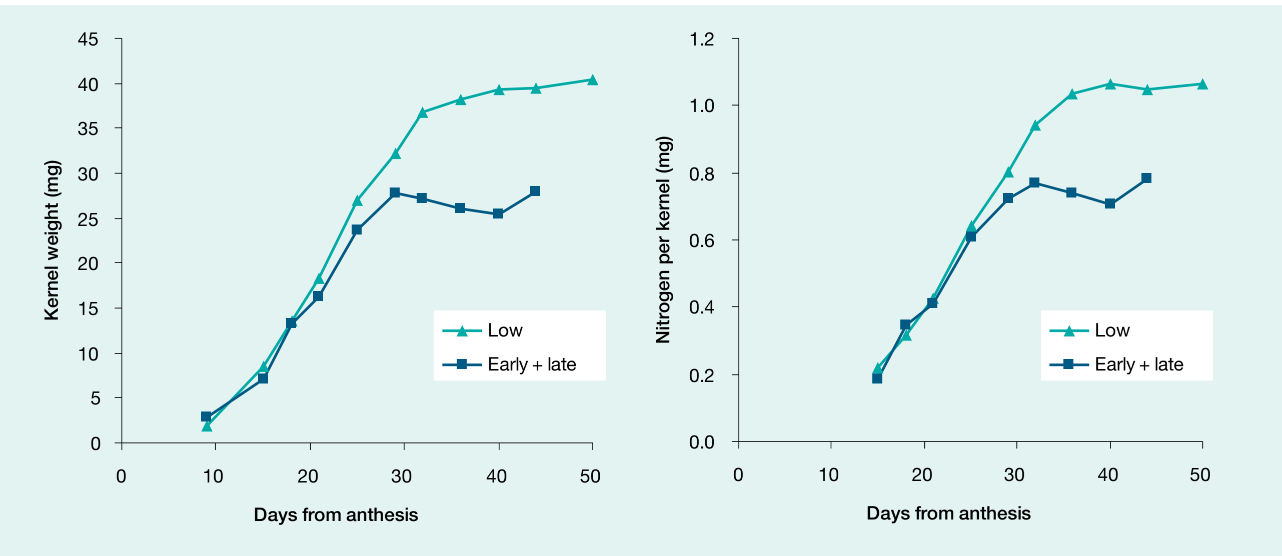

FIGURE 2 Influence of water stress on wheat grain growth and nitrogen accumulation in the field at Condobolin. Water stress was applied before and after anthesis (early + late). Final protein concentrations were 13.6% (low) and 14.4% (early + late)



increments. Yield was maximised with nitrogen application of 90kg/ha. Protein increased linearly for each 30kg/ha increment up to 120kg/ha nitrogen. In this trial, yield appeared to be maximised at a grain protein concentration of 11.2%, a useful ‘rule of thumb’ in deciding whether a crop was yield limited by nitrogen.

Grain protein by variety interactions

It is generally considered that there are only minor differences among commercial varieties in regard to grain protein accumulation. However, there have been suggestions from growers and agronomists that, relative to other varieties, Gregory⊕ has a lower grain protein concentration. It must be noted though that Gregory⊕ has demonstrated wide adaptation across grain growing regions in NSW with high relative yields, good stripe rust resistance, high level of tolerance to root lesion nematode (*Pratylenchus thornei*), flexibility with sowing date and classification as an AH or APH variety depending on the region.

NVT data

Variety comparisons for protein accumulation are difficult because of the ‘dilution’ effect from variations in grain yield. In a preliminary study, the relationship between grain yield and protein was examined using results from the NVT trial network. This approach has some limitations as the protein measurements are not replicated at each site and it was not possible to weight individual sites according to the precision of the trial, but the large number of sites lends confidence to the findings. Gregory⊕ was compared with Sunvale, a variety with similar phenology and quality, together with the newly released Spitfire⊕, using the 103 main season NVT trials (since 2008) in which all three varieties were present. Across these sites, Gregory⊕ was the highest yielding variety and Sunvale was the lowest, while Gregory⊕ had the lowest and Spitfire⊕ the highest grain protein concentration.

A regression analysis of grain yield and grain protein concentration showed the expected dilution effect, with protein decreasing as yield increased. The slope of this relationship was similar for the three varieties, grain protein decreasing by 0.6 percentage units for each 1t/ha of yield increase. However, grain protein at any yield level differed significantly ($P<0.001$) among varieties, with the value for Gregory⊕ being 0.8 lower than Sunvale. This lends support to the observations made by growers and agronomists but the magnitude of the difference is probably not enough to influence variety choice. In contrast, Spitfire⊕ protein values were 1.5 units higher than Gregory⊕ across all yield levels.

Varietal differences in grain protein concentration and the relationship between yield and grain protein were examined further using information from the GRDC-funded VSAP project, using a sowing time trial at Condobolin and nitrogen use efficiency trials at Condobolin and Parkes, all done during 2011.

Condobolin sowing date trial

Grain yield and protein values for 14 main season wheat varieties sown on three dates at Condobolin during 2011 are presented in Figure 4. Gregory⊕ (and Waagan) grain protein values were significantly lower than the other varieties (11.6 *cf*. 12.7) whereas Spitfire⊕ was much higher (14.4 *cf*. 12.7). All varieties followed the trend of reduced protein with increased yield, at a rate of 0.6 percentage units for each 1t/ha of yield increase. The lower protein of Gregory⊕ was only partly explained by its grain yield, while Spitfire⊕ achieved greater protein concentration than other varieties at all yield levels.

Condobolin NUE trial

The Condobolin NUE trial contained nine wheat varieties sown at five nitrogen rates. There was no significant effect of nitrogen rate on grain yield but the effect on protein was significant with protein increasing with rates of applied nitrogen. As for the sowing time trial, there was a negative correlation between grain yield and grain protein concentration, and Gregory⊕ did not differ from other varieties. Once again Spitfire⊕ was an exception achieving a protein concentration about 1.5 units higher than expected from its yield.

Parkes NUE trial

At Parkes nine wheat varieties were sown at five nitrogen rates, from 0 to 120kg/ha. Eight of the nine varieties (including

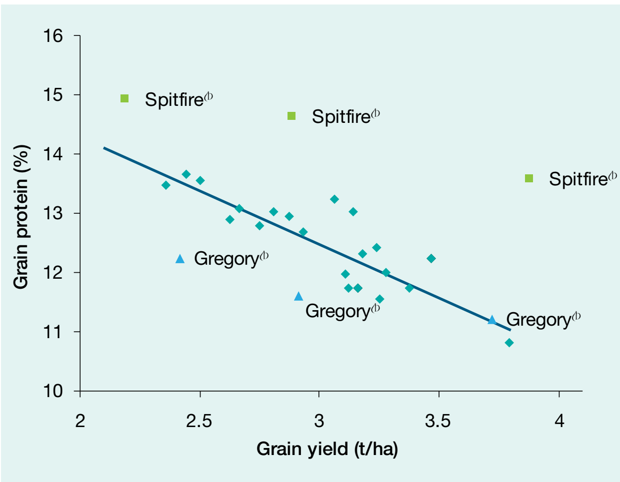

FIGURE 4 Grain yield and grain protein of 14 main season wheat varieties for three sowing dates at Condobolin during 2011. The trendline (excluding Gregory⊕ and Spitfire⊕) shows that grain yield and grain protein were negatively correlated ($R^2 = 0.74$). LSDs were 0.30 (yield) and 0.27 (protein)

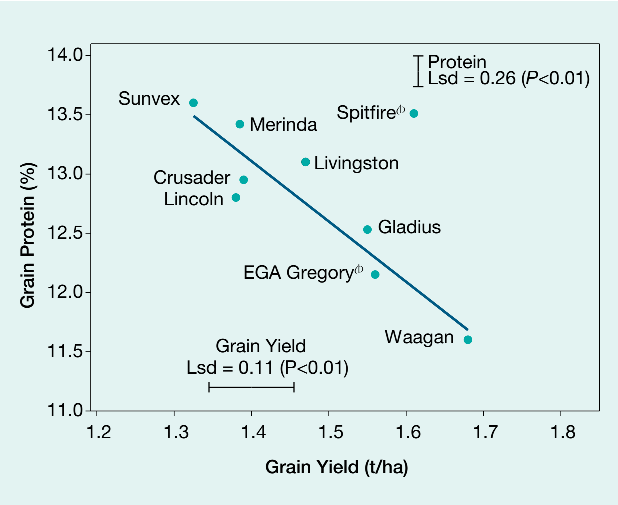

FIGURE 5 Grain yield and protein for nine wheat varieties averaged across five nitrogen rates at Condobolin in 2011. The trendline shows that, excluding Spitfire$^{\Phi}$, grain yield and grain protein concentration were negatively correlated (R^2 = 0.69)

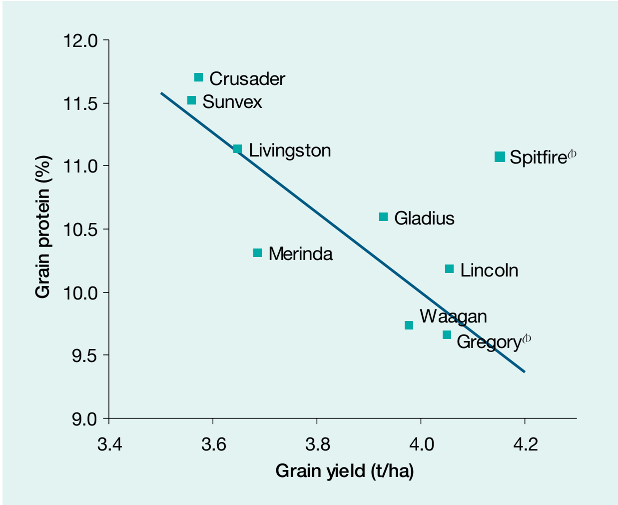

FIGURE 6 Grain yield and protein for nine wheat varieties averaged across five nitrogen rates at Parkes during 2011. The trendline shows that, excluding Spitfire$^{\Phi}$, grain yield and grain protein concentration were negatively correlated (R^2 = 0.76). LSDs were 0.24 (yield) and 0.35 (protein)

Gregory$^{\Phi}$) followed the general negative correlation between grain yield and grain protein concentration. The exception was Spitfire$^{\Phi}$ which produced a relatively high grain protein concentration at a high yield level (see Figure 6). The slope of the protein dilution relationship at this site was quite steep (3% protein per t/ha), and gross returns may have been higher with a lower yielding variety (for example, Crusader, Sunvex) achieving a higher grain protein.

Discussion

The analysis of NVT data and the 2011 trial results confirmed the negative correlation between grain yield and grain protein concentration, although the slope of the relationship varied greatly among sites. For the biggest data set, the NSW NVT trials, grain protein decreased by 0.6 percentage units for each 1t/ha of yield increase for the three varieties examined. The relative importance of yield and protein will depend on grain prices and particularly the spread between grades. The situation is further complicated by the re-emergence of 'cliff-face' pricing and by price volatility at harvest time.

The results also suggest that Gregory$^{\Phi}$ may sometimes achieve somewhat lower protein concentrations at a given yield level than other mainstream varieties. In the NVT trials, Gregory$^{\Phi}$ was 0.8 percentage points lower than Sunvale, and at Condobolin it also fell below expected proteins for its yield level in some comparisons. In others, it grouped closely with other varieties on the yield/protein relationship, achieving lower protein levels only as a result of higher yield. Overall, the magnitude of the difference from other varieties


Photo: Catriona Nicholls



is probably not enough to influence variety choice, given the high yield and other attributes of Gregory⌽.

The performance of Spitfire⌽ was particularly interesting. In the NVT trials, Spitfire⌽ achieved protein concentrations that were 0.6% units higher than Sunvale and 1.5% higher than Gregory⌽. In the 2011 trials, Spitfire⌽ had protein values 1.5 to 2.5% units higher than other varieties at the same yield level. These findings need to be confirmed and work is underway to investigate the mechanisms of this response. Meanwhile, producers and agronomists are advised to treat this information cautiously and select varieties based on their overall agronomic package rather than on one trait in isolation.

While this paper has focussed on genotypic responses, these play a relatively minor role in determining grain protein compared to nitrogen nutrition and environmental conditions during grain filling. Future work within the VSAP project will investigate whether nitrogen rates or timing should vary for different varieties, especially with regard to varieties such as Gregory⌽ and Spitfire⌽.

SPONSORS

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ACKNOWLEDGEMENTS

Jim Presley, Nick Moody, Katrina McDougall, Linda Brangwin and Scott Boyd are thanked for their expert assistance in the field and laboratory.

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Variable rate nitrogen application in a cropping system

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Key points

- During 2011 an opportunity arose to assess the response of Hyola 601 Roundup Ready® canola across three different soil types and four different application rates of urea in the Inverleigh district of south-west Victoria.
- Canola vegetative dry matter increased significantly as the application rate of urea increased.
- There were no statistically significant differences in estimated yield as the applied rate of urea increased, due mostly to in-crop variability; however the average estimated yield per hectare increased as the applied rate of urea increased.
- The maximum marginal return on investment (ROI) for sandy soil was achieved by applying 180kg/ha of urea. Within the loam soil zone the rate of 165kg/ha of urea achieved the maximum ROI, while in the clay soil zone the maximum ROI was achieved by applying 115kg/ha of urea.
- This analysis emphasises the importance of managing different soil types using zone-based application of inputs.

Aim

An opportunity to evaluate the response of Hyola 601 Roundup Ready canola across three soil zones (sandy, loam and clay) to various rates of nitrogen (urea) fertiliser in the Inverleigh district of south-west Victoria arose during 2011.

Method

Four nitrogen levels were applied (0, 65, 115 and 130kg/ha urea) at the rosette growth stage in a strip trial layout, which passed through different paddock soil zones. A 50kg/ha blanket rate of urea was applied to the entire trial paddock just before flowering. Each treatment was applied in 60m-wide strips. The final applications of nitrogen for each treatment are shown in Table 1. Unfortunately, because this was an opportunistic assessment, a replicated trial was not possible. However a reasonably thorough sampling strategy was developed to assess the effects of soil zones and urea rates on biomass production and estimated yield.

An EM38 survey was completed on the paddock during 2010 to determine the locations of different soil types in the paddock. From this it was concluded that the paddock was composed of sandy, loam and clay soils (see Figure 1). Pre-designated sample points that covered all soil types and all urea treatments were identified throughout the paddock.

Biomass and plant count measurements and yield estimates were calculated for all soil zones through which the different nitrogen treatment strips passed. Dry matter (DM) was determined from randomly sampled plants that were dried in an oven at 65°C until constant weight. The dry mass per plant was then multiplied by the number of plants per square metre.

Marginal returns on investment (ROI) were calculated on different urea rates in the three paddock soil zones.

TABLE 1 Urea treatments completed on paddock Y09 (nitrogen rate is calculated from urea treatment assuming that urea = 46% nitrogen)

Urea treatment (kg/ha)	Nitrogen rate (kg/ha)
0 + 50	23.0
65 + 50	52.9
115 + 50	75.9
130 + 50	82.8

Results

There were no significant differences in plant density across the different soil zones (see Figure 2) or across the different urea treatments (see Figure 3). The biomass cuts and plant counts, from which DM was estimated, were completed on 8 September 2011 (see Figure 4). A second estimation of vegetative DM was completed on 17 October 2011 (see Figure 5).

In terms of estimated yields, there were no statistically significant differences in yield as the rate of additional urea increased, due mostly to in-crop variability; however the average estimated yield per hectare increased as the rate of additional urea increased (see Figure 6).

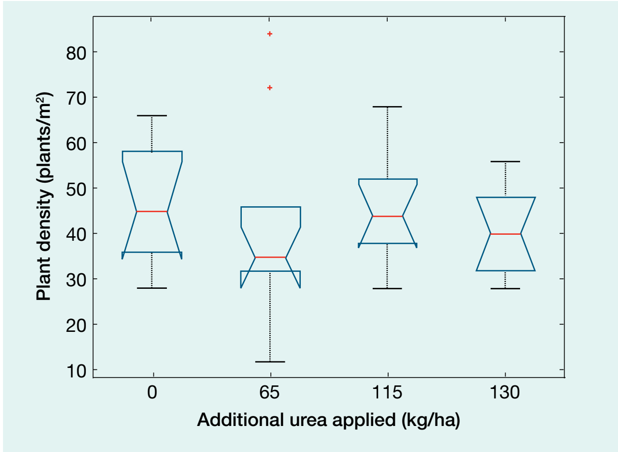

FIGURE 3 Box plots of plant density as a function of applied urea

FIGURE 1 Sampling plan: yellow zone = sandy, red zone = loam, blue zone = clay. (Lines across the paddock indicate the boundaries of the fertiliser treatment strips and the numbers represent the pre-designated sampling points.)

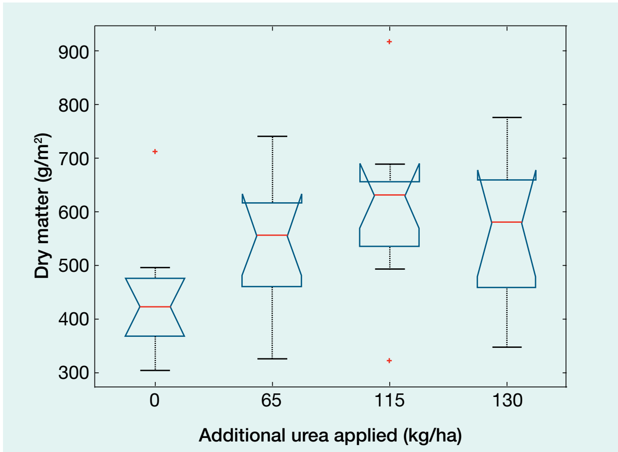

FIGURE 4 Box plots of crop dry matter as a function of applied urea at 8 September 2011

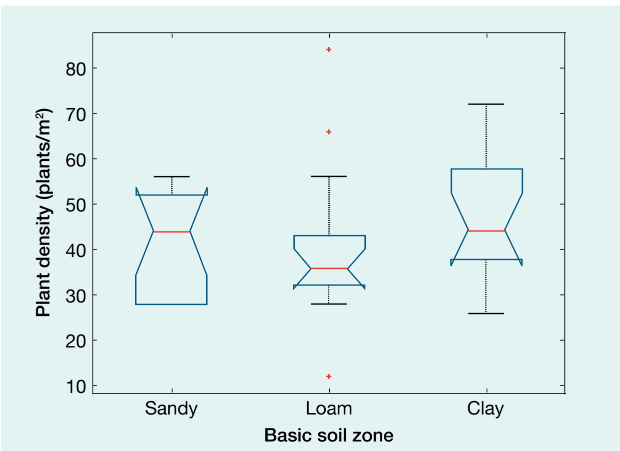

FIGURE 2 Box plots of plant density as a function of soil zone

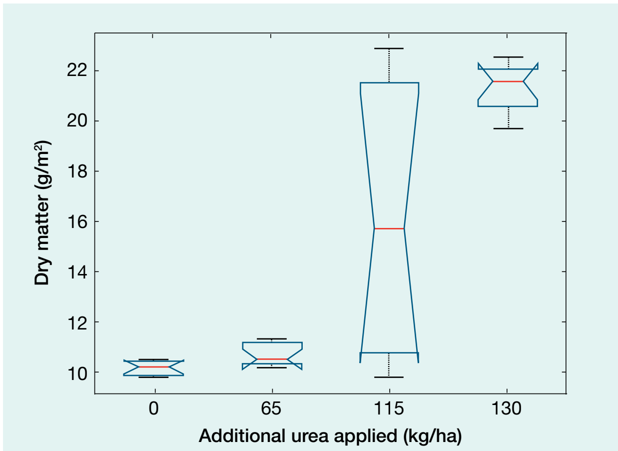

FIGURE 5 Box plots of crop dry matter as a function of applied urea at 17 October 2011

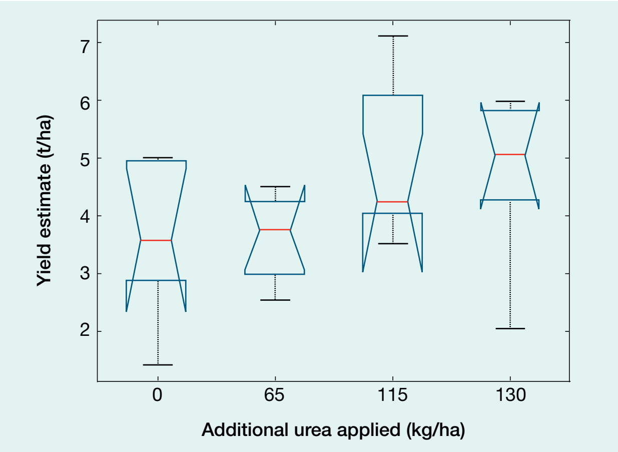

FIGURE 6 Box plots of crop yield estimates as a function of applied urea

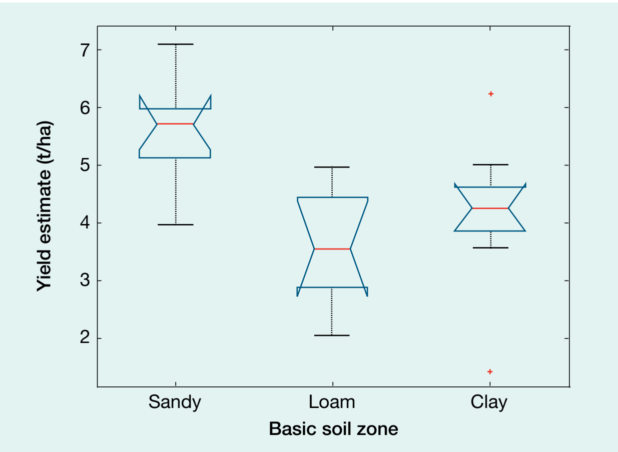

FIGURE 7 Box plots of crop yield estimates as a function of soil zone

The sandy soil zone had a significantly higher estimated yield across all urea treatments (5.60t/ha) compared with the loam (3.59t/ha) and clay (4.16t/ha) soil zones (see Figure 7).

Observations and comments

Because the plant densities were effectively the same across all the soil types (see Figure 2) and all the urea treatments (see Figure 3), differences in vegetative biomass and estimated yield can be directly attributed to soil type and urea responses.

Within the sandy soil zone the maximum marginal returns on investment (ROI) of $3.29 return per $1 spent on urea was achieved by applying 180kg/ha of urea (130kg/ha + 50kg/ha). Within the loam soil zone the rate of 165kg/ha of urea (115kg/ha + 50kg/ha) achieved the maximum ROI of $7.82 return per $1 spent on urea, while in the clay soil zone the maximum ROI of $11.72 return per $1 spent on urea was achieved by applying 115kg/ha of urea (65kg/ha + 50kg/ha). These analyses emphasise the importance of managing different soil types using zone-based application of inputs.

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A comparison of a biosolids-based organic fertiliser with mono ammonium phosphate

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Key points

- There was no statistical difference in crop performance between using biosolids and MAP provided the application rate of the biosolids matched the necessary phosphorous requirements of the crops.
- Suitably processed biosolids could become a viable source of fertiliser in the future.

Aim

The aim of this trial was to determine whether a biosolids-based product could be used as an alternative to inorganic phosphate fertilisers in a broadacre cropping system.

Broadacre agriculture in Australia relies heavily on inorganic phosphate fertiliser to improve crop yields. However, the availability of rock phosphates will decrease in the future and consequently the price of phosphate fertilisers will increase if no viable alternative is found. One alternative is to incorporate organic based sources of phosphorous into broadacre farming systems.

Biosolids are waste products from community waste-water treatment plants. Biosolids management has become more important as the population has increased and the procedures for their disposal have become more regulated.

Method

The trial was run at the Dookie Campus of the University of Melbourne with an average rainfall of 551.3mm per year. The biosolid used in this experiment was obtained from the Macspred manufacturing plant in Ballarat and is composed of 70% organic matter with an average pH of 6.1. On a wet weight basis it contained 4% nitrogen, 2% phosphorous and 0.5% potassium. The biosolid compound was compared with mono ammonium phosphate (MAP) with a phosphorous content of 21%.

The experimental design consisted of a randomised block design with four replicates of seven treatments. The plots were $200m^2$ and were sown using an NDF air seeder with a 10m-wide bar. Row spacing averaged 36.83cm and the seed was sown at the same depth as the fertiliser.

Treatments 1 (BSA1) and 2 (BSA2) consisted of biosolid treatments applied using two different techniques at a rate matching the available phosphorous content of the MAP fertiliser. To achieve the recommended MAP application rate of 80kg/ha, the biosolids were applied at a rate of 1965.07kg/ha. Treatment 1 biosolids were sown with the seed using the air seeder while Treatment 2 biosolids were broadcast onto the plots and incorporated into the soil at sowing.

Treatments 3 (BST1) and 4 (BST1) matched the phosphorous level of the MAP with the total phosphorous level of the biosolids, which equated to a biosolids rate of 491.26kg/ha per plot. In Treatment 3 the biosolids were applied with the seed at sowing, while in Treatment 4 the biosolids were broadcast onto the plots before sowing.

Treatments 5 (MAP1) and 6 (MAP2) applied a rate of 80kg/ha of MAP with the MAP of Treatment 5 applied with the seed at sowing and the MAP of Treatment 6 applied before sowing, using the broadcast method.

Application of biosolids to Treatment 1 and 2 plots (1965.07kg/ha) was achieved over three applications. The first application applied the biosolids with the seed while the next two applications used the air seeder to distribute the biosolids across the plot but without cultivating the soil. A GPS was used to apply the biosolids directly on top of the furrow. In treatments requiring the fertiliser to be applied via the broadcast method, an air seeder was used to apply the fertiliser over the plots without disturbing the soil.

Break strips were situated throughout the trial site to allow normal management operations of the crop to occur without disturbing the trial. These strips were used as a control for the experiment.

Plant counts were taken for each of the treatments at early seedling growth (GS: 11–12). Two biomass cuts were taken: one at early tillering (GS: 21–23) and the other at early milk development (GS: 71–73). Plants in the biomass cuts were cut 5cm off the ground. The biomass was then dried in a forced air oven at 60°C for at least 72 hours before being weighed.

Results

There were no significant differences in plant counts between the various treatments (see Figure 1).

There were significant differences in biomass between treatments at the early tillering stage (see Figure 2); however there were no significant differences in biomass between treatments at the early milk development stage (see Figure 3).

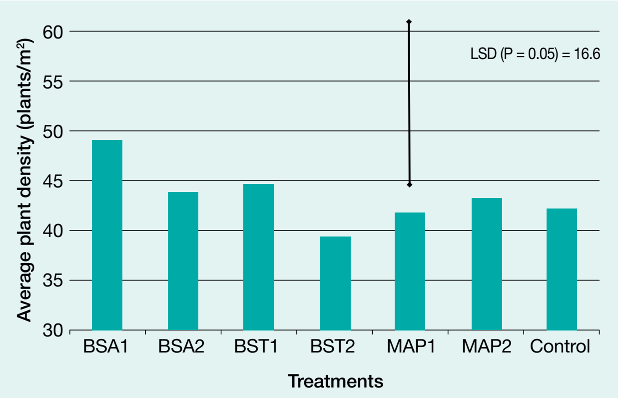

FIGURE 1 Average plant densities for each treatment

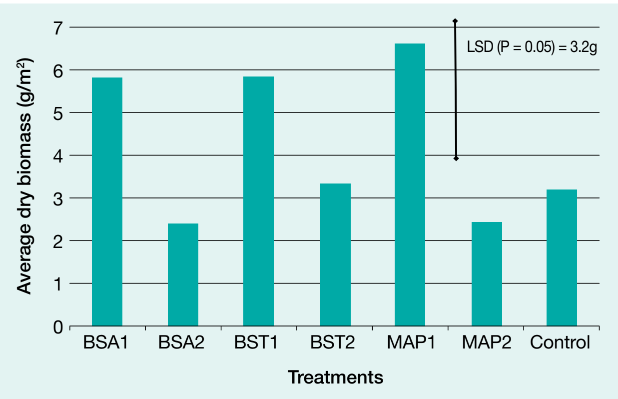

FIGURE 2 Average dry biomass for each treatment on 26 July 2011

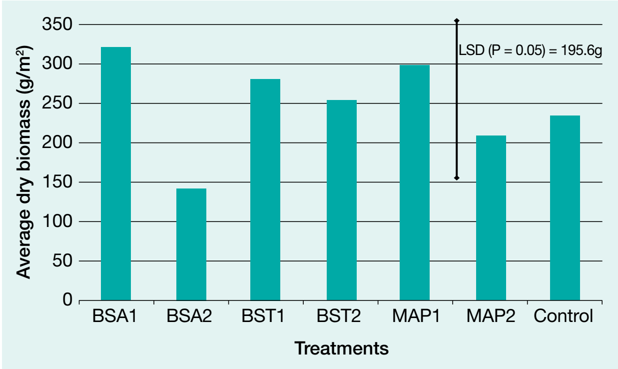

FIGURE 3 Average dry biomass for each treatment on 12 October 2011

Observations and comments

The differences between treatments at the first biomass cut can be attributed to the variation in tiller numbers between the treatments. However compensatory growth between the first and second biomass cut resulted in non-significant differences between treatments in the final biomass assessment.

Treatments with fertiliser applied via the broadcast technique were hindered in their early growth, but recovered as plants matured.

There was no statistical difference in crop performance between using biosolids and MAP, provided the application rate of the biosolids matched the necessary phosphorous requirements of the crops. Therefore, suitably processed biosolids could become a viable source of fertiliser in the future.

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North east Victoria National Variety Testing Trials 2011

Trials conducted by Agrisearch and NSW DPI. Data collated by Geoff Stratford (DPI Victoria, Horsham) and Dale Grey (DPI Victoria, Cobram) from data provided by the NVT website.

During the 2011 trials, the Dookie, Wunghnu, Yarrawonga and Rutherglen wheat trials were sprayed for stripe rust.

The Rutherglen oat trial and the Dookie faba bean trial had results too variable for publication.

TABLE 1 Long-term predicted wheat yield (main season) for 2005–2011 in north east Victoria, and the number of site years in that area

Variety	Yield (t/ha)	% of Ruby	Site years
Scout	3.19	104	5
Espada	3.10	101	16
Impala	3.10	101	8
Waagan	3.10	101	11
Axe	3.07	100	19
Bullet	3.07	100	9
Correll	3.07	100	19
GBA Hunter	3.07	100	5
GBA Ruby	3.07	100	19
Corack	3.04	99	5
Estoc	3.04	99	11
Gladius	3.04	99	19
Pugsley	3.04	99	14
Young	3.04	99	17
Gascoigne	3.01	98	9
Magenta	3.01	98	12
EGA Gregory	2.98	97	19
Emu Rock	2.98	97	5
Lincoln	2.98	97	14
Spitfire	2.98	97	11
Wallup	2.98	97	5
Yitpi	2.98	97	19
Barham	2.95	96	19
Catalina	2.95	96	13
Guardian	2.95	96	8
Justica CL Plus	2.95	96	5
Livingston	2.95	96	16
Merinda	2.95	96	11
Preston	2.95	96	6
Sunguard	2.95	96	5
Bowie	2.92	95	16
Derrimut	2.92	95	19
Elmore CL Plus	2.92	95	3

TABLE 1 (Continued)

Variety	Yield (t/ha)	% of Ruby	Site years
Orion	2.92	95	11
Fang	2.89	94	3
Peake	2.89	94	19
Sabel CL Plus	2.89	94	5
Sentinel	2.89	94	16
Ventura	2.89	94	19
Beaufort	2.86	93	7
Janz	2.86	93	15
Kord CL Plus	2.86	93	5
Tammarin Rock	2.86	93	5
Wyalkatchem	2.86	93	15
Bolac	2.82	92	16
Gauntlet	2.82	92	3
Giles	2.82	92	5
Yenda	2.82	92	13
Annuello	2.79	91	10
Clearfield Stl	2.79	91	5
EGA Wentworth	2.79	91	8
Frame	2.79	91	18
Sunvex	2.79	91	5
Dakota	2.76	90	9
EGA Wills	2.76	90	9
Ellison	2.76	90	5
GBA Sapphire	2.76	90	4
Kennedy	2.73	89	7
Chara	2.70	88	19
Clearfield Jnz	2.70	88	8
Crusader	2.70	88	9
EGA Wylie	2.70	88	4
SQP Revenue	2.70	88	7
EGA Bounty	2.67	87	6
Impose CL Plus	2.67	87	3
Rosella	2.61	85	14
Forrest	2.58	84	6



TABLE 2 Long-term predicted wheat yield (long season) for 2005–2011 in north east Victoria

Variety	Yield (t/ha)	% of Wedgetail	Total # trials
Preston	3.33	118	4
Beaufort	3.27	116	6
Bolac	3.02	107	6
SQP Revenue	2.96	105	5
EGA Gregory	2.96	105	7
Estoc	2.93	104	3
Sentinel	2.93	104	6
Espada	2.90	103	3
Endure	2.88	102	4
Yenda	2.88	102	4
Derrimut	2.85	101	3
Mansfield	2.85	101	4
Barham	2.85	101	5
EGA Eaglehawk	2.82	100	4
EGA Wedgetail	2.82	100	7
Sunzell	2.79	99	4
Forrest	2.76	98	3
EGA Bounty	2.76	98	4
Kennedy	2.74	97	3
Naparoo	2.74	97	3
Kellalac	2.74	97	7
Chara	2.71	96	7
Amarok	2.59	92	3

TABLE 3 Yield and quality of wheat varieties during 2011 at Dookie (main season)

Variety	Yield (t/ha)	Hectolitre weight (kg/hL)	Protein (%)	Screenings <2.0mm (%)	Seed size (g/1000 seeds)
Corack	5.37	77.4	11.6	0.79	52
QAL2000	5.27	71.4	9.9	1.45	44
Espada	5.14	74.0	12.1	1.83	44
Kord CL Plus	5.07	75.1	11.5	2.28	50
Magenta	5.00	74.4	11.1	2.12	44
Correll	4.99	74.2	10.9	2.65	46
Scout	4.99	78.2	11.5	1.58	44
Clearfield Stl	4.98	78.4	12.6	1.06	42
Justica CL Plus	4.98	73.7	11.9	0.66	40
Lincoln	4.91	74.9	11.1	1.57	46
Livingston	4.90	75.2	12.8	0.97	42
Yitpi	4.87	76.8	11.3	1.25	48
Wyalkatchem	4.85	74.4	11.7	0.64	46
Gauntlet	4.80	77.6	11.5	1.01	46
Estoc	4.79	77.1	11.9	1.04	44
Emu Rock	4.78	74.3	12.0	2.14	52
Bolac	4.77	74.1	11.7	3.30	34
GBA Ruby	4.76	75.6	11.8	1.06	44
Peake	4.76	72.6	11.4	1.57	40
EGA Gregory	4.73	66.4	11.4	0.94	44
Gascoigne	4.71	75.4	12.0	1.06	46
Gladius	4.71	74.2	10.7	1.30	48
Sentinel	4.68	73.5	10.0	0.80	44
Spitfire	4.68	77.0	11.3	2.10	46
Barham	4.67	70.8	10.2	0.64	42
Impala	4.66	75.2	11.1	1.17	34
Sabel CL Plus	4.66	74.7	11.3	1.35	50
Wallup	4.62	76.4	11.2	0.58	42
Sunguard	4.61	76.8	10.6	2.05	44
Chara	4.60	76.8	12.5	1.90	42
Bowie	4.58	72.3	11.2	1.38	42
Kennedy	4.58	73.9	12.3	1.46	42
Orion	4.57	68.7	10.6	0.97	42
Derrimut	4.56	77.4	11.6	1.22	38
Young	4.52	75.5	11.6	0.97	40
Axe	4.51	73.6	11.7	1.55	48
Ventura	4.51	75.5	11.7	1.01	44
Elmore CL Plus	4.47	77.5	12.0	1.90	38
Frame	4.29	77.4	11.9	0.95	48
Clearfield Jnz	4.17	77.1	11.5	0.73	44
SQP Revenue	4.16	71.3	10.0	2.09	36
Forrest	4.14	75.1	12.2	2.50	26
Sown	6 May 2011				
Harvest	15 December 2011				
Site mean (t/ha)	4.72				
CV (%)	5.55				
LSD (t/ha)	0.45				



TABLE 4 Yield and quality of wheat varieties during 2011 at Wunghnu (main season)

Variety	Yield (t/ha)	Hectolitre weight (kg/hL)	Protein (%)	Seed size (g/1000 seeds)
Espada	3.83	78.78	9.1	48
EGA Gregory	3.63	81.06	9.2	42
Corack	3.60	80.02	8.6	50
Estoc	3.59	80.96	10.1	46
Orion	3.57	71.50	8.1	48
Emu Rock	3.50	78.98	9.2	54
GBA Ruby	3.47	80.40	9.1	44
Axe	3.45	77.86	9.9	48
Barham	3.45	74.06	8.1	44
Correll	3.42	76.32	8.1	50
Bolac	3.39	77.88	8.8	36
Scout	3.36	81.86	8.9	46
Livingston	3.33	78.86	9.6	44
Magenta	3.31	80.22	8.9	50
SQP Revenue	3.31	71.92	7.7	36
Kord CL Plus	3.27	78.22	9.2	52
Ventura	3.26	79.50	9.1	46
Elmore CL Plus	3.21	81.80	8.9	42
Gauntlet	3.21	80.92	10.0	48
QAL2000	3.19	76.98	8.4	48
Spitfire	3.19	82.28	9.3	50
Sunguard	3.17	79.52	9.3	44
Wallup	3.16	79.78	9.9	42
Sentinel	3.15	77.50	9.3	44
Clearfield Stl	3.14	81.56	9.2	48
Gascoigne	3.14	79.60	10.1	46
Impala	3.12	78.16	8.8	38
Gladius	3.10	77.40	9.4	50
Kennedy	3.05	78.04	10.0	42
Lincoln	3.03	78.88	9.1	46
Sabel CL Plus	3.03	78.78	9.2	50
Justica CL Plus	3.02	77.90	9.6	44
Yitpi	3.02	79.26	9.2	50
Peake	2.99	78.80	9.6	44
Clearfield Jnz	2.95	80.08	9.5	44
Derrimut	2.90	80.10	9.3	42
Bowie	2.71	76.36	8.6	44
Forrest	2.66	79.28	8.6	42
Frame	2.50	81.26	10.1	50
Chara	2.44	79.96	10.1	42
Sown	**9 May 2011**			
Harvest	**3 Dec 2011**			
Site mean (t/ha)	**3.18**			
CV (%)	**7.61**			
LSD (t/ha)	**0.41**			

TABLE 5 Yield and quality of wheat varieties during 2011 at Yarrawonga (main season)

Variety	Yield (t/ha)	Hectolitre weight (kg/hL)	Protein (%)	Screenings <2.0mm (%)	Seed size (g/1000 seeds)
EGA Gregory	5.90	77.7	9.7	1.21	44
Emu Rock	5.87	75.9	11.2	3.02	52
Scout	5.87	79.9	11.0	2.52	46
Corack	5.70	77.2	10.2	1.27	50
Correll	5.70	73.2	10.4	3.70	48
Orion	5.60	72.0	9.3	1.41	46
Impala	5.53	75.7	10.0	1.32	38
Elmore CL Plus	5.52	78.9	9.9	1.91	40
Lincoln	5.51	75.7	10.3	3.08	46
Ventura	5.46	77.9	11.4	1.14	44
Yitpi	5.46	76.2	10.8	2.04	48
Sentinel	5.43	72.9	10.7	1.19	46
Espada	5.41	74.2	11.7	1.90	46
Justica CL Plus	5.40	75.0	11.4	0.90	44
Magenta	5.40	77.9	10.6	1.67	48
Gascoigne	5.39	76.8	11.6	3.17	48
Clearfield Stl	5.38	79.4	10.5	2.68	48
Wallup	5.36	75.9	11.7	0.90	42
GBA Ruby	5.35	76.5	10.7	3.28	46
Kord CL Plus	5.31	75.3	11.2	3.72	50
Sunguard	5.31	74.4	10.7	2.30	44
Axe	5.30	74.4	11.0	2.22	48
Bolac	5.30	76.0	10.3	2.04	36
Livingston	5.30	75.8	11.8	1.52	44
Estoc	5.29	78.4	11.6	1.34	46
Barham	5.28	73.9	10.3	1.97	40
Gladius	5.28	74.2	11.4	2.52	48
Peake	5.28	74.9	11.1	2.33	42
Chara	5.24	76.3	11.0	0.88	42
Spitfire	5.20	79.1	12.2	3.26	50
Clearfield Jnz	5.18	76.8	11.2	0.77	42
Sabel CL Plus	5.16	75.5	11.6	2.61	50
SQP Revenue	5.14	73.9	9.2	4.61	40
Kennedy	5.12	75.7	11.4	2.03	44
Derrimut	5.06	77.4	11.1	2.00	40
Gauntlet	4.86	77.8	10.9	0.98	46
Forrest	4.70	77.0	10.9	4.82	40
Sown	**16 May 2011**				
Harvest	**13 December 2011**				
Site mean (t/ha)	**5.38**				
CV (%)	**4.86**				
LSD (t/ha)	**0.41**				



TABLE 6 Yield and quality of long-season wheat varieties during 2011 at Rutherglen

Variety	Yield (t/ha)	Hectolitre weight (kg/hL)	Protein (%)	Screenings <2.0mm (%)	Seed size (g/1000 seeds)
Preston	6.24	71.7	9.5	1.1	46
SQP Revenue	5.62	71.9	8.5	1.8	46
Beaufort	5.44	71.0	9.3	3.6	46
Sentinel	5.39	73.7	10.4	0.8	50
QAL2000	5.15	73.2	9.1	0.6	54
EGA Wedgetail	5.11	71.7	10.0	0.7	48
Forrest	5.10	75.8	9.8	2.0	48
Barham	5.08	72.0	9.9	0.7	50
EGA Bounty	5.06	76.8	9.6	0.6	48
Espada	5.01	73.8	10.7	0.7	52
Mansfield	4.84	71.2	9.4	1.3	40
Chara	4.81	74.7	10.6	0.7	46
Bolac	4.80	73.9	10.5	2.1	40
EGA Gregory	4.78	77.2	11.0	1.1	50
Derrimut	4.72	76.2	10.3	0.8	46
Kennedy	4.68	74.8	11.6	0.6	52
Sunguard	4.68	76.4	11.3	1.1	48
Kellalac	4.67	74.0	10.0	1.5	42
Estoc	4.38	75.2	10.7	1.2	52
Bowie	4.22	72.7	10.3	0.6	50
Orion	4.03	68.7	8.3	0.5	54
Sown	5 May 2011				
Harvest	20 December 2011				
Site Mean (t/ha)	5.00				
CV (%)	8.74				
LSD (t/ha)	0.62				

TABLE 7 Long-term predicted triticale yield for 2005–2011 in north east Victoria

Variety	Yield	Total # trials
Chopper	3.21	8
Hawkeye	3.21	12
Berkshire	3.18	10
Canobolas	3.17	10
Jaywick	3.15	12
Bogong	3.14	10
Tobruk	3.10	10
Rufus	3.01	8
Tahara	2.91	14
Tickit	2.91	5
Yowie	2.89	4
Crackerjack	2.79	4
Tuckerbox	2.76	6
Abacus	2.69	4
Kosciuszko	2.32	6

TABLE 8 Yield of triticale varieties during 2011 at Rutherglen

Variety	Yield (t/ha)	Hectolitre weight (kg/hL)	Protein (%)	Screenings < 2.0mm (%)	Seed size (g/1000 seeds)
Bogong	4.84	70.4	9.5	1.6	52
Jaywick	4.74	66.5	9.7	1.0	50
Chopper	4.54	67.8	10.1	0.7	48
Canobolas	4.48	69.2	9.8	3.1	52
Hawkeye	4.48	69.0	9.5	1.0	48
Goanna	4.37	66.8	9.9	1.0	52
Rufus	4.32	67.9	10.1	0.8	52
Yowie	4.30	68.9	9.8	1.3	50
Berkshire	4.19	67.9	10.6	1.4	50
Tuckerbox	4.08	69.4	9.6	3.4	46
Tahara	3.74	66.2	9.8	1.4	50
Sown	**5 May 2011**				
Harvest	**22 December 2011**				
Site mean (t/ha)	**4.42**				
CV (%)	**9.35**				
LSD (t/ha)	**0.67**				

TABLE 9 Yield of triticale varieties during 2011 at Yarrawonga

Variety	Yield (t/ha)	Hectolitre weight (kg/hL)	Protein (%)	Screenings <2.0mm (%)	Seed size (g/1000 seeds)
Hawkeye	5.68	67.6	10.4	2.0	46
Bogong	5.67	70.7	10.6	3.6	44
Chopper	5.41	62.5	10.5	3.0	40
Jaywick	5.38	69.6	10.4	2.1	44
Goanna	5.20	71.5	11.4	1.9	40
Canobolas	5.13	71.1	11.3	4.2	46
Tahara	4.97	67.1	11.0	1.3	42
Rufus	4.74	67.9	10.8	3.1	44
Yowie	4.59	67.4	11.2	1.7	42
Tuckerbox	4.11	67.3	10.3	4.0	34
Sown	**17 May 2011**				
Harvest	**14 December 2011**				
Site Mean (t/ha)	**5.35**				
CV (%)	**4.86**				
LSD (t/ha)	**0.41**				

TABLE 10 Long-term predicted barley yield for 2005–2011 in north east Victoria

Variety	Yield (t/ha)	Total # trials
Hindmarsh	2.88	5
Oxford	2.83	3
Fleet	2.81	6
Henley	2.77	3
Lockyer	2.76	3
Wimmera	2.76	3
Skipper	2.75	3
Capstan	2.74	6
Keel	2.73	5
Commander	2.69	6
Fairview	2.69	3
Hannan	2.66	3
Yarra	2.66	5
Buloke	2.65	6
Westminster	2.63	3

TABLE 11 Yield and quality of barley varieties at Wunghnu during 2011

Variety	Yield (t/ha)	Hectolitre weight (kg/hL)	Protein (%)	Screenings <2.0mm (%)	Plumpness >2.5mm (%)	Seed size (g/1000 seeds)
Oxford	3.97	65.9	7.2	0.9	96.2	44
Hindmarsh	3.87	66.4	8.2	1.1	96.7	44
SY Rattler	3.87	66.2	8.1	1.1	96.3	42
Macquarie	3.86	67.0	7.7	2.6	94.1	48
Fairview	3.84	66.8	7.9	0.7	98.2	46
Skipper	3.78	65.4	7.7	1.1	97.1	48
Henley	3.77	62.8	7.8	1.1	98.0	48
Fathom	3.76	63.5	8.1	1.3	96.9	52
Shepherd	3.73	64.8	7.9	0.7	97.6	48
Wimmera	3.65	64.1	7.9	0.8	89.5	46
Westminster	3.62	67.0	8.3	1.0	97.3	50
Fleet	3.54	61.7	8.1	0.1	96.8	54
Capstan	3.48	62.5	7.5	2.0	90.2	46
Gairdner	3.45	67.1	8.0	0.8	96.1	50
Scope	3.33	66.6	8.7	6.9	97.8	52
Keel	3.22	65.8	8.2	1.8	96.0	48
Buloke	3.19	66.4	8.0	0.7	97.8	52
Commander	3.09	64.6	7.3	2.0	94.2	46
Finniss	3.01	69.7	8.8	3.2	69.3	42
Flagship	2.97	67.0	8.2	1.5	96.4	50
Baudin	2.95	67.6	8.3	0.5	98.7	44
Schooner	2.84	67.6	8.3	1.1	96.8	46
Navigator	2.74	64.7	7.7	1.8	92.7	42
Sown	9 May 2011					
Harvest	3 December 2011					
Site mean (t/ha)	3.5					
CV (%)	6.25					
LSD (t/ha)	0.37					

TABLE 12 Long-term predicted oat yield for 2005–2011 in north east Victoria and the number of site years in that area

Variety	Yield (t/ha)	Site years
Bannister	2.43	3
Quoll	2.38	8
Potoroo	2.16	7
Mitika	2.12	10
Possum	2.11	10
Wombat	2.11	6
Dunnart	2.10	9
Kojonup	2.03	5
Yallara	1.96	10
Euro	1.90	10
Mortlock	1.61	6
Numbat	1.12	4

TABLE 13 Yield of oat varieties at Yarrawonga during 2011

Variety	Yield (t/ha)	Hectolitre weight (kg/hL)	Protein (%)	Screenings <2.0mm (%)	Seed size (g/1000 seeds)
Quoll	1.92	41.2	13.3	8.2	38
Bannister	1.57	42.9	10.7	15.4	40
Yallara	1.51	44.1	10.9	10.9	36
Wombat	1.16	40.9	11.3	22.2	38
Dunnart	1.06	39.0	10.6	6.0	42
Mitika	1.05	44.1	12.6	8.7	34
Possum	0.82	38.7	12.1	8.9	34
Euro	0.78	35.0	10.4	18.5	34
Numbat	0.3	40.3	9.0	43.1	28
Sown	17 May 2011				
Harvest	14 December 2011				
Site mean (t/ha)	1.17				
CV (%)	11.14				
LSD (t/ha)	0.21				

TABLE 14 Yield of oat varieties at Dookie during 2011

Variety	Yield (t/ha)	Hectolitre weight (kg/hL)	Protein %	Screenings < 2.0mm (%)	Seed size (g/1000 seeds)
Quoll	2.90	43.9	12.4	13.5	38
Bannister	2.85	49.2	11.0	9.5	38
Mitika	2.36	46.6	12.4	4.3	42
Possum	2.00	64.6	11.6	5.3	40
Wombat	1.97	46.5	11.5	12.8	40
Dunnart	1.85	44.9	10.0	3.6	42
Euro	1.82	42.8	10.7	14.5	40
Yallara	1.80	49.1	10.9	6.2	40
Numbat	1.38	42.2	12.4	26.8	32
Sown	6 May 2011				
Harvest	15 Dec 2011				
Site mean (t/ha)	2.11				
CV (%)	10.2				
LSD (t/ha)	0.33				



TABLE 15 Yield of Roundup Ready canola varieties at Yarrawonga during 2011

Variety	Yield (t/ha)	Oil (%)	Protein (%)
HC1050	2.29	43.6	19.8
Hyola 505RR	2.22	47.0	19.2
Victory V5001RR	2.15	45.3	20.1
CB Frontier RR	2.14	42.7	20.6
IH50 RR	2.07	42.9	19.7
Hyola 404RR	2.04	48.1	17.6
Victory V5002RR	2.02	44.4	19.6
GT Cobra	1.96	45.7	18.5
GT Viper	1.89	44.6	19.3
GT Taipan	1.88	44.9	17.3
Pioneer 45Y22 (RR)	1.88	43.3	20.1
Pioneer 46Y20 (RR)	1.84	45.4	20.2
GT Cougar	1.78	42.5	19.7
GT Mustang	1.77	44.5	19.1
CB Eclipse RR	1.75	41.7	20.6
GT Scorpion	1.57	41.2	20.6
Sown	**13 May 2011**		
Harvest	**17 Nov 2011**		
Site mean (t/ha)	**1.97**		
CV (%)	**9.05**		
LSD (t/ha)	**0.3**		

TABLE 16 Yield of Roundup Ready canola varieties at Wunghnu during 2011

Variety	Yield (t/ha)	Oil (%)	Protein (%)
Hyola 404RR	1.76	49.1	16.1
Victory V5001RR	1.67	42.6	20.1
HC1050	1.64	45.4	17.4
Victory V5002RR	1.64	46.8	15.8
GT Cobra	1.63	46.3	17.7
IH50 RR	1.59	-	-
GT Viper	1.55	45.9	16.6
GT Mustang	1.48	44.7	18.8
Hyola 505RR	1.48	48.3	17.5
CB Frontier RR	1.47	42.0	19.6
Pioneer 45Y22 (RR)	1.47	45.0	19.0
CB Eclipse RR	1.46	43.5	16.4
GT Cougar	1.25	42.7	18.0
GT Taipan	1.19	41.1	18.2
Pioneer 46Y20 (RR)	1.03	48.0	17.6
GT Scorpion	-	40.7	18.8
Sown	**30 May 2011**		
Harvest	**30 November 2011**		
Site mean (t/ha)	**1.48**		
CV (%)	**9.55**		
LSD (t/ha)	**0.28**		

TABLE 17 Long-term predicted mid-season imidazolinone-tolerant (imi) canola yield for 2005–2011 in north east Victoria and the number of site years in that area

North East	Yield (t/ha)	Site years
Pioneer 44Y84CL	1.66	7
Pioneer 46Y83CL	1.60	7
Hyola 676CL	1.59	2
Hyola 575CL	1.58	4
Pioneer 45Y82CL	1.55	7
Hyola 571CL	1.50	5
Hyola 474CL	1.48	2
Pioneer 46Y78	1.46	7
Pioneer 43Y85CL	1.41	2
Pioneer 44C79CL	1.32	3

TABLE 18 Yield and quality of mid-season imidazolinone-tolerant (imi) canola varieties at Yarrawonga during 2011

Variety	Yield (t/ha)	Oil (%)	Protein (%)
Hyola 575CL	2.30	43.5	21.3
Pioneer 46Y83 (CL)	2.29	-	-
Pioneer 44Y84 (CL)	2.22	-	-
Pioneer 45Y82 (CL)	2.02	44.0	19.5
Hyola 474CL	1.96	44.4	19.3
Sown	**13 May 2011**		
Harvest	**17 Nov 2011**		
Site mean (t/ha)	**2.19**		
CV (%)	**7.73**		
LSD (t/ha)	**0.26**		

TABLE 19 Long-term predicted yield of mid-season triazine-tolerant (TT) canola varieties for 2005–2011 in north east Victoria and the number of site years in that area

Variety	Yield (t/ha)	Site years
CB Henty HT	1.79	2
Crusher TT	1.73	4
Hyola 555TT	1.72	4
CB Junee HT	1.60	3
Hyola 751TT	1.59	4
CB Jardee HT	1.57	7
Thumper TT	1.56	4
ATR Snapper	1.51	4
ATR Stingray	1.51	4
Monola 77TT	1.47	7
CB Tumby HT	1.45	5
Fighter TT	1.45	2
CB Mallee HT	1.43	4
Hyola 444TT	1.43	4
ATR Cobbler	1.41	9

TABLE 20 Yield and quality of mid-season triazine-tolerant (TT) canola varieties during 2011 at Wunghnu

Variety	Yield (t/ha)	Oil (%)	Protein (%)
Monola 77TT	1.95	44.8	20.2
Hyola 555TT	1.69	42.5	21.1
CB Jardee HT	1.67	41.3	20.4
CB Henty HT	1.64	40.5	21.0
Bonanza TT	1.63	45.1	19.1
ATR Stingray	1.62	44.8	20.0
Crusher TT	1.61	41.9	19.6
Monola 605TT	1.59	43.6	19.3
CB Junee HT	1.52	41.0	21.4
Monola 707TT	1.48	42.5	23.2
Thumper TT	1.47	43.0	21.5
Hyola 751TT	1.42	41.3	22.7
CB Mallee HT	1.40	41.6	19.6
ATR Snapper	1.33	47.0	17.4
Monola 76TT	1.30	44.3	20.5
Hyola 444TT	1.25	42.2	22.7
CB Scaddan	1.23	39.6	21.4
ATR Cobbler	1.22	39.2	22.3
Tawriffic TT	1.11	44.4	20.2
Monola 506TT	-	45.1	19.7
Sown	3 May 2011		
Harvest	30 November 2011		
Site mean (t/ha)	1.47		
CV (%)	13.65		
LSD (t/ha)	0.4		

TABLE 21 Yield and quality of mid-season triazine-tolerant (TT) canola varieties during 2011 at Yarrawonga

Variety	Yield (t/ha)	Oil (%)	Protein (%)
CB Henty HT	2.20	43	20.3
Crusher TT	2.13	44	19.7
Hyola 751TT	2.06	44	21.1
Monola 77TT	1.92	47	19.1
CB Jardee HT	1.87	44	20.1
Thumper TT	1.83	44	21.6
ATR Snapper	1.81	47	19.6
ATR Gem	1.76	46	19.2
Hyola 555TT	1.75	43	21.0
CB Scaddan	1.74	42	21.2
CB Mallee HT	1.72	41	20.5
Hyola 444TT	1.72	44	21.8
Monola 506TT	1.71	46	20.1
CB Junee HT	1.70	42	19.9
Monola 605TT	1.58	44	20.5
Tawriffic TT	1.57	46	19.7
ATR Cobbler	1.53	45	19.2
Monola 76TT	1.47	46	19.9
ATR Stingray	1.45	46	20.3
Monola 707TT	1.43	44	22.8
Bonanza TT	1.41	42	23.0
Sown	13 May 2011		
Harvest	21 November 2011		
Site mean (t/ha)	1.7		
CV (%)	9.78		
LSD (t/ha)	0.29		

TABLE 22 Yield and quality of lupin varieties during 2011 sown at Diggora

	Yield (t/ha)	100 seed weight (g/100 seeds)
Mandelup	1.97	34.37
Coromup	1.68	34.27
Jenabillup	1.68	33.65
PBA Gunyidi	1.53	29.92
Wonga	1.31	31.70
Sown	27 May 2011	
Harvest	17 December 2011	
Site mean (t/ha)	1.61	
CV (%)	12.4	
LSD (t/ha)	0.32	



Local herbicide resistance data revealed

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Key points

- Resistance to Group A 'fop' and B herbicides is common across southern NSW.
- Resistance levels are lower in the north-west of the surveyed area than the south and the east.
- Resistance to the Group A 'dim' clethodim is less common than other Group A and B herbicides.
- Levels of resistance are lower in wild oat populations than annual ryegrass.
- There is minimal resistance to simazine and glyphosate in wild oats and annual ryegrass.

Herbicide resistance is a major problem in the cropping regions of southern Australia. Identifying resistance levels is crucial for designing management strategies for herbicide resistance.

The weed samples reported on in this paper came either from growers and agronomists across Australia using the herbicide resistance testing service at Charles Sturt University (CSU) or via two recent resistance surveys carried out in southern New South Wales. In the surveys samples of weed seeds were collected every 10km from paddocks along roadsides in southern NSW. Seed samples obtained via both sources were then grown out in a glasshouse and screened for resistance using a variety of herbicides.

Annual ryegrass

Samples sent into the herbicide resistance testing service at CSU showed significant levels of resistance, irrespective of the point of origin (see Table 1). There was some variability in herbicide resistance across the NSW cropping zones, with lower levels of resistance found in areas of lower cropping intensity.

TABLE 1 Percentage of ryegrass samples sent to the CSU herbicide resistance testing service that were classified as resistant

State	Samples	A 'fop' (%)	A 'dim' (%)	B (%)	C (%)	D (%)
NSW	1492	83	18	54	1	5
Vic	900	83	24	37	1.5	14
WA	863	78	28	72	0.1	3
SA	674	69	14	32	0.5	15
Tas	15	100	28	77	7	7

Samples sent into the testing service are already suspected of resistance and may not represent the actual level of resistance within the cropping regions from which they were selected. To obtain a true measure of herbicide resistance in these areas the weed seeds need to be collected randomly from cropping paddocks across a specific area. Two such surveys were carried out across the southern NSW cropping area east (2007) and west (2010) of a line from Forbes through Temora to Corowa (see Figure 1).

In the 2007 survey a high proportion of annual ryegrass samples were classified as resistant to diclofop (81%) and the two Group B herbicides, chlorsulfuron (70%) and imazaic-imazapyr (65%) (see Table 2). The level of resistance to clethodim was lower (21%) but still significant. Resistance to the other tested herbicides simazine, trifluralin and glyphosate was much lower.

The proportion of samples resistant for all herbicides was about 70% lower in the 2010 survey than the 2007 survey (see Table 3). None of the samples were resistant to simazine, trifluralin or glyphosate in the 2010 survey.

While the level of resistance in the 2010 survey was lower than that of the 2007 survey, across both surveys resistance was much higher in some areas than others. For example, resistance levels were higher south of the Sturt Highway (Wagga Wagga to Narrandera) than north-west of the Newell Highway (Narrandera to West Wyalong). South of Sturt Highway 65% of samples were resistant to diclofop compared with 41% in the north-west. Similarly, 68% of samples from south of Sturt Highway were resistant to chlorsulfuron compared with 36% of samples in the north-west. For imazapic/imazapyr the resistance levels were 49% (south) and 24% (north-west) while for tralkoxydim the resistance levels were 47% (south) and 16% (north-west).

The only other herbicide resistance survey of southern NSW was carried out during 1991 when it was found that resistance levels for diclofop were 14%, sethoxydim 12%

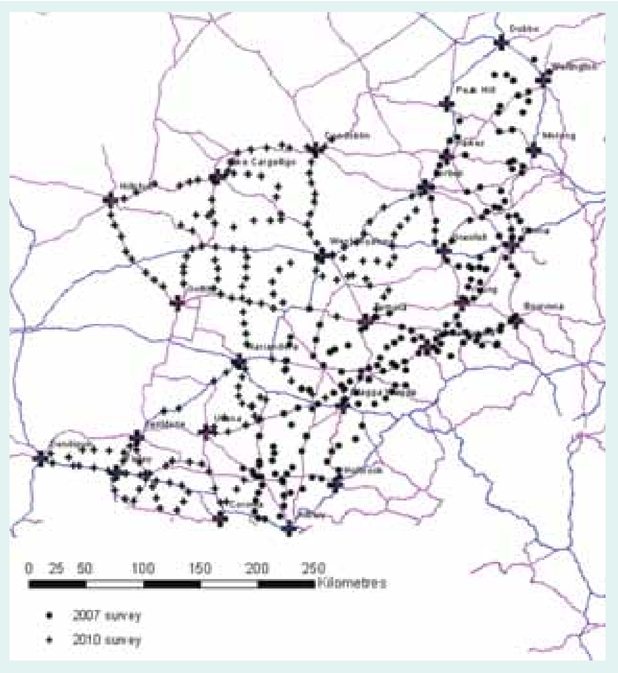

FIGURE 1 Location of sample sites for the 2007 and 2010 NSW surveys

chlorsulfuron 11% and trifluralin 12%. Resistance levels to diclofop and chlorsulfuron have therefore increased markedly with a less marked increase for the Group A 'dims' (sethoxydim and tralkoxydim). However the tralkoxydim results are from the western survey only, while the level of trifluralin resistance has remained constant.

Cross resistance levels

Very few paddocks were susceptible to all five main selective herbicide groups tested (Groups A 'fop', A 'dim', B, C and D). In the eastern survey only 9% of samples were susceptible to all groups compared with 18% of samples in the west. Thirty-one per cent of samples in the eastern survey were resistant to three herbicide groups and 3% of samples to four herbicide groups. In the west, 21% of samples were resistant to three groups and no samples were resistant to four herbicide groups.

Wild oats

More than 600 wild oat samples have been received by the CSU herbicide resistance testing service since 1994 with most (88%) of these coming from NSW. Of the samples received from NSW, 65% were resistant to Group A 'fop' herbicides, 8% to 'dims', 6% to Group B and 7% to flamprop-methyl. Like ryegrass, most samples were suspected of resistance and therefore the actual herbicide levels are likely to be lower.

To date, only the wild oats from the eastern survey have been analysed with significant levels of resistance found to diclofop and flamprop (see Table 4).

TABLE 2 Herbicide resistance levels in annual ryegrass collected during the 2007 NSW survey

Herbicide	Resistant	Developing resistance	Susceptible	Number tested	% total resistance*
Diclofop	94	15	25	134	81
Clethodim	15	12	104	131	21
Chlorsulfuron	59	25	36	120	70
Imazapic/imazapyr	68	10	42	120	65
Simazine	1	0	119	120	1
Trifluralin	2	5	113	120	6
Glyphosate	1	0	126	127	1

* Total resistance = resistant + developing resistance

TABLE 3 Herbicide resistance levels in annual ryegrass collected during the 2010 NSW survey

Herbicide	Resistant	Developing resistance	Susceptible	Number tested	% total resistance*
Diclofop	53	16	55	124	56
Clethodim	3	2	118	123	4
Tralkoxydim	23	16	84	123	32
Chlorsulfuron	49	14	57	120	53
Imazapic/imazapyr	33	11	73	117	38
Simazine	0	0	117	117	0
Trifluralin	0	0	109	109	0
Glyphosate	0	0	121	121	0

* Total resistance = resistant + developing resistance

  

TABLE 4 Herbicide resistance levels in wild oats collected during the 2007 NSW survey

Herbicide	Resistant	Developing resistance	Susceptible	Number tested	% total resistant
Diclofop	30	13	70	113	38
Clethodim	0	0	108	108	0
Mesosulfuron	0	0	83	83	0
Triallate	0	0	72	72	0
Flamprop	5	6	94	105	10
Glyphosate	0	0	97	97	0

* Total resistance = resistant + developing resistance

Conclusion

The results of the two surveys indicate that despite annual ryegrass and wild oats displaying significant herbicide resistance these species remain susceptible to some herbicides. However care needs to be taken to maintain the life of these effective herbicides, as there will be increased selection pressure placed on them due to the high levels of resistance to other herbicides.

SPONSORS

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Inversions — how do we identify them and learn not to spray?

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Key points

- Danger period for spray application is 1.5 hours before sunset until 1.5 hours after sunrise.
- Inversions are more likely in calm conditions and on clear nights.
- Inversions are less likely in windy conditions or during heavy cloud coverage.
- Coarse to very coarse sprays and a suitable Delta T will not prevent spray drift if inversions are present.
- Applicators must recognise weather conditions that contribute to the formation of surface temperature inversions.
- Night spraying requires continual weather monitoring.
- Avoid night spraying at wind speeds of less than 11km/h.

Background

Spraying is about placing the correct dose of chemical on the right target, at the right time. To achieve this, it is important to understand more about application than merely the water volume intended for application over a given area. Spray operators also need to be able to identify weather conditions associated with inversions.

The Australian Pesticide and Veterinary Medicines Authority (APVMA) has raised the stakes on application management. During 2008 the APVMA released *Operating Principles in Relation to Spray Drift Risk.* The APVMA's actions to mitigate drift is a response to the "off-target movement of pesticide outside the intended application area at the time or soon after application".

New requirements are now located on some product labels outlining sprayer setup in relation to droplet size, weather conditions and the hazards of night spraying. The Estercide Xtra 680 label is a prime example:

> **Spray applications and drift risk assessment**
>
> *USE ONLY when wind is more than 3km/hour and less than 15/km/hour as measured by an anemometer at the application site.*
>
> *USE ONLY coarse to very coarse spray according to the ASAE S572 definition for standard nozzles.*
>
> - *Check, determine and record the weather conditions immediately before and immediately after the spray application is made.*
> - *Record — Temperatures*
>   - *— Relative humidity*
>   - *— Delta T*
>   - *— Wind speed (min 3km/h, max 15km/h)*
>   - *— Is there a temperature inversion?*
> - *Night spraying — extra care is required to ensure that inversion conditions are not present. Use smoke generators to determine wind direction and presence of inversion conditions.*

The importance of inversion layers and their drift potential is underplayed in these warnings.

The modelling the APVMA uses to determine drift risk does not allow for droplet behaviour under the presence of an inversion. It is also fair to say that the relationship between temperature and relative humidity, or Delta T, is only part of the weather observations that may or may not lead to drift. Case studies from the Clare Valley, South Australia and Colbinabbin Ranges, Victoria highlight how complex weather systems can create off-target damage.

The real danger for an applicator is to think that coarse to very coarse sprays will reduce drift risk at all times. Coarse to very coarse sprays will still move and cause off-target damage under inversion conditions. This was evident during the 2010 summer spraying within the central west New South Wales. Extensive damage to many paddock trees, including kurrajongs, was obvious throughout the region. New technologies, such as GPS, facilitated night spraying and operators chasing a low Delta T found themselves spraying under inversion conditions.

What is an inversion and how do you identify it?

Normally, the atmospheric temperature decreases with height above the Earth's surface. However, an inversion occurs when there is an increase in temperature as you move above the Earth's surface. This is created by cooling of the Earth's surface after sunset. The air close to the surface cools faster than the air above. Cold air has a tendency to sink and as a result the cold air close to the surface does not mix with the warmer air above it.

Visual indications of inversion are:

- Fog
- Dew
- Frost
- Smoke or dust hanging in the air or moving laterally in a concentrated package.

However, the absence of these visual indicators does not mean there is no inversion. A significant drop in wind speed near sunset is a classic indicator of the potential for an inversion. The greater the difference between the maximum daytime and minimum night time temperatures, the stronger the inversion. In Australia, inversions occur on most nights from early evening until several hours after sunrise (see Figure 1).

Windy conditions generally prevent the build-up of inversion conditions, whereas calm nights provide the environment for inversions to intensify. Wind speeds continuously greater than 11km/h significantly reduce the formation of temperature inversions.

Spraying under inversion conditions traps driftable droplets, or vapour, in concentrated layers. One of the challenges with night spraying is higher humidity, which enables droplet survival. These concentrated layers may be shifted by localised winds and the path taken under calm conditions by these winds is the same route that water would flow down through a catchment. Drift under inversion conditions has the potential to move much further than wind-driven droplet drift. The challenge for applicators is to identify inversion conditions and cease spraying as they may be contributing to a cumulative regional effect.

Inversion layers burn off as the Earth's surface is heated by the sun. This opens the Earth's surface to the atmosphere that was present above the inversion. Pesticide that is trapped under the inversion can then be taken away by the prevailing winds (see Figure 2).

Conclusions

Nothing can be adjusted on a spray unit to prevent drift under inversion conditions. Spraying needs to stop and resume only when the conditions are suitable. Night spraying greatly increases the risk for off-target movement of pesticide because temperature inversions generally

FIGURE 1 Inversion layer

FIGURE 2 Inversion layer — chemical concentrating at base of inversion

occur at night. Applicators must continually monitor weather conditions to ensure spraying only occurs under optimal conditions.

If the occurrence of drift onto susceptible crops continues, it is possible that further restrictions will be legislated within the next 10 years. These restrictions will affect weather parameters for night spraying and maximum allowable groundspeed for all applications.

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FURTHER INFORMATION

- *Surface Inversions for Australian Agricultural Regions,* Graeme Tepper, from the Australian Pesticide Veterinary Medicines Authority, www.apvma.gov.au
- *Code of Practice for Summer Weed Control* Government of South Australia www.pir.sa.gov.au/biosecuritysa/ruralchem
- *Spraywise: Top Tips for Drift Reduction* Nufarm
- *Spraywise Broadacre Application Handbook* Jorg Kitt (second edition)
- *Sprayer risk management and boom sprayer management* (videos) DPI Victoria website.

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