RiverinePlains

Research for the Riverine Plains 2011

A selection of research relevant to agriculture in the Riverine Plains

Farmers inspiring farmers



Research for the Riverine Plains 2011

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
Sub-editing by Hot Tin Roof Communications
Design and layout by Redtail Trading Pty Ltd

PLATINUM SPONSORS

agribusiness nab

RSM Bird Cameron Chartered Accountants

GOLD SPONSORS

GASON

GOLDACRES CHANGE THE WAY YOU SPRAY

O'CONNORS Horsham • Warracknabeal • Birchip • Shepparton • Corowa CASE IH AGRICULTURE

RURAL FINANCE Let's talk

syngenta®

SILVER SPONSORS

AGA	Hutcheon & Pearce/Hutcheon A&G	Nufarm
CBH Group	Incitec Pivot	Pacific Seeds
Commonwealth Bank	Louis Dreyfus Commodities	Rabobank
Elders Insurance	Murray CMA	

BRONZE SPONSORS

AGT Seeds	IK Caldwell	SST Development Group/Trimble
Baker Seed Co	Nuseed	Suncrop Bank
Belmores	Pioneer Hi-Bred Australia	Viterra
Canola Breeders	Preston Rowe Paterson	
Hunter Rural	Sibelco/Lilydale Aglime	

EXECUTIVE SUPPORT

NSW GOVERNMENT Primary Industries

State Government Victoria Department of Primary Industries

Acknowledgements

Welcome to the 2011 edition of the Riverine Plains Inc (RPI) trial book.

After almost a decade of drought, the 2010 cropping season was shaping up to be one of the best. After a generally on-time start to the season, the dominant La Nina pattern delivered plentiful winter and spring rains, which set crops up nicely for high yields and a return to farm profitability. Even the locusts didn't do as much damage to winter crops as was predicted. But in grain farming, it's never over until it's safely in the silo and the extended harvest rains took the gloss off what could have been a truly terrific year for most.

The 2010 season presented an altogether different set of challenges than those thrown up by the dry conditions we've become all too familiar with. High stubble loads at sowing, pest and disease pressures, nitrogen timing, wet paddocks and soggy tracks were just a few of the operational issues we faced.

The wet spring and harvest also caused varying degrees of hardship across our membership area. Some crops were completely wiped out by floods while others had yields reduced by waterlogging. To some extent, most farmers in the region were also affected by quality downgrading at harvest. In general though, yields seemed to be high to very high and solid prices made up for some of the quality issues.

Those very same challenges were also an issue for those managing research or demonstration trials across the region. Many trials were not harvested or had large yield variations, which made them unsuitable for rigorous interpretation. But there are always lessons to be learnt and the 2010 trial book hopes to share with you some of that learning. To this end, this year's trial book contains the usual mix of Riverine Plains' own research as well as other local research, summary reports and evaluations, which we hope you find valuable.

Once again, Riverine Plains research features heavily in the book and I thank the RPI trial managers, authors and sponsors for their dedication and hard work in preparing their work for publication. I would like to thank Nick Poole and Tracey Wylie of the Foundation for Arable Research (NZ), John Seidel of Agricultural Research Services and committee member Adam Inchbold for their contributions on the water use efficiency project articles. I would also like to thank Brett Whelan, Peter Baines, Adam Inchbold and Mark Harmer for their contribution regarding RPI's ongoing precision agriculture work and The University of Melbourne and RPI Research sub-committee chair, David Cook for the summer cropping project work and write-up.

In addition to our own research, we again have drawn from research carried out outside the Riverine Plains area because we feel this adds to our understanding of farming in this region. Some of this research comes from as far away as Western Australia, and while our soil types and climate are different, there are many similarities in our situations. We hope you will appreciate the different perspective these articles bring.

On behalf of RPI, I'd like to formally thank all the authors for their submissions. We sincerely appreciate the efforts of our sponsors, research organisations and industry bodies in contributing material to share with our members.

We would like to particularly thank the Victorian DPI and NSW DPI for their contributions and also extend our appreciation to John Sykes Rural Consulting for his continued support.

Special thanks also go to Fiona Hart, Riverine Plains dedicated administration officer and Catriona Nicholls from Hot Tin Roof Communications for their work in obtaining articles, liasing with authors and working closely with designer Josephine Eynaud from Redtail Trading to produce a readable and visually appealing publication.

As ever, we hope this year's trial book will be useful and interesting, and that it will support your decision-making in some way. We wish you all the best for the 2011 cropping season and we have our fingers crossed for a season that's not too dry, not too wet — but just right.

Michelle Pardy

Technical Content Editor



Contents

Area covered by Riverine Plains Inc

Membership area



2011 Riverine Plains Inc Committee

COMMITTEE			
Chairman	Andrew Russell	Browns Plains	0417 401 004
Deputy Chairman	Evan Ryan	Yarrawonga	0428 298 031
Immediate Past Chairman	Adam Inchbold	Yarrawonga	(03) 5743 1749
Treasurer	Jan Davis	Corowa	(02) 6032 4196
Administration Sub-committee Chair	Jan Davis	Corowa	(02) 6032 4196
Research Sub-committee Chair	David Cook	Pine Lodge South	(03) 5829 2263
Extensions Sub-committee Chair	Ingrid Inchbold	Yarrawonga	0427 458 863
Sponsorship Sub-committee Chair	Peter White	Yarrawonga	0428 445 903
Membership Sub-committee Chair	Cameron Swann	Oaklands	0429 208 056
	Ben Bailey	Brocklesby	(02) 6029 4368
	John Bruce	Barooga	(03) 5876 2229
	Joe Corrigan	Burrumbuttock	0429 933 923
	Steven Dore	Urana	(02) 6920 8361
	Allison Glover	Wilby	0400 604 887
	Andrew Godde	Culcairn	(02) 6029 8332
	Mark Harmer	Dookie	0417 318 869
	Barry Membrey	Albury	(02) 6058 6749
	Michelle Pardy	Barooga	(03) 5873 4795
	Craig Sharam	West Wodonga	(02) 6059 1033
	Denis Tomlinson	Daysdale	(02) 6035 0270
	David Wolfenden	Rand	(02) 6029 5243
EXECUTIVE SUPPORT			
DPI Victoria	Dale Grey	Cobram	(03) 5871 0600
NSW DPI	Janet Walker	Albury	(02) 6051 7700

ADMINISTRATION

Administrative Officer

Fiona Hart
Riverine Plains Inc
PO Box 386 YARRAWONGA VIC 3730
Phone: (03) 5744 1713
Fax: (03) 5743 1740
Email: info@riverineplains.com.au
Web site: www.riverineplains.com.au

Disclaimer

This publication is prepared in good faith by members of Riverine Plains Inc, on the basis of the information available to us at the date of publication, without any independent verification. Neither Riverine Plains Inc, nor any contributor to the publication represents that the contents of this publication are accurate or complete, nor do we accept any responsibility for any errors or omissions in the contents however they may arise. Readers who act on information from this advice do so at their own risk.

Riverine Plains Inc and contributors may identify products or proprietary or trade names to help readers identify particular types of products. We do not endorse or recommend the products of any manufacturers referred to. Other products may perform as well as, or better than those specifically referred to.

Any research with unregistered pesticides or of unregistered products reported in this document does not constitute a recommendation for that particular use by the authors, the authors' organisation or the management committee. All pesticide applications must accord with the currently registered label for that particular pesticide, crop, pest and region.

Units of measurement

Row spacings

A number of trials carried out during 2010 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

metres — m

hectares — ha

millimetres — mm

kilograms — kg

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

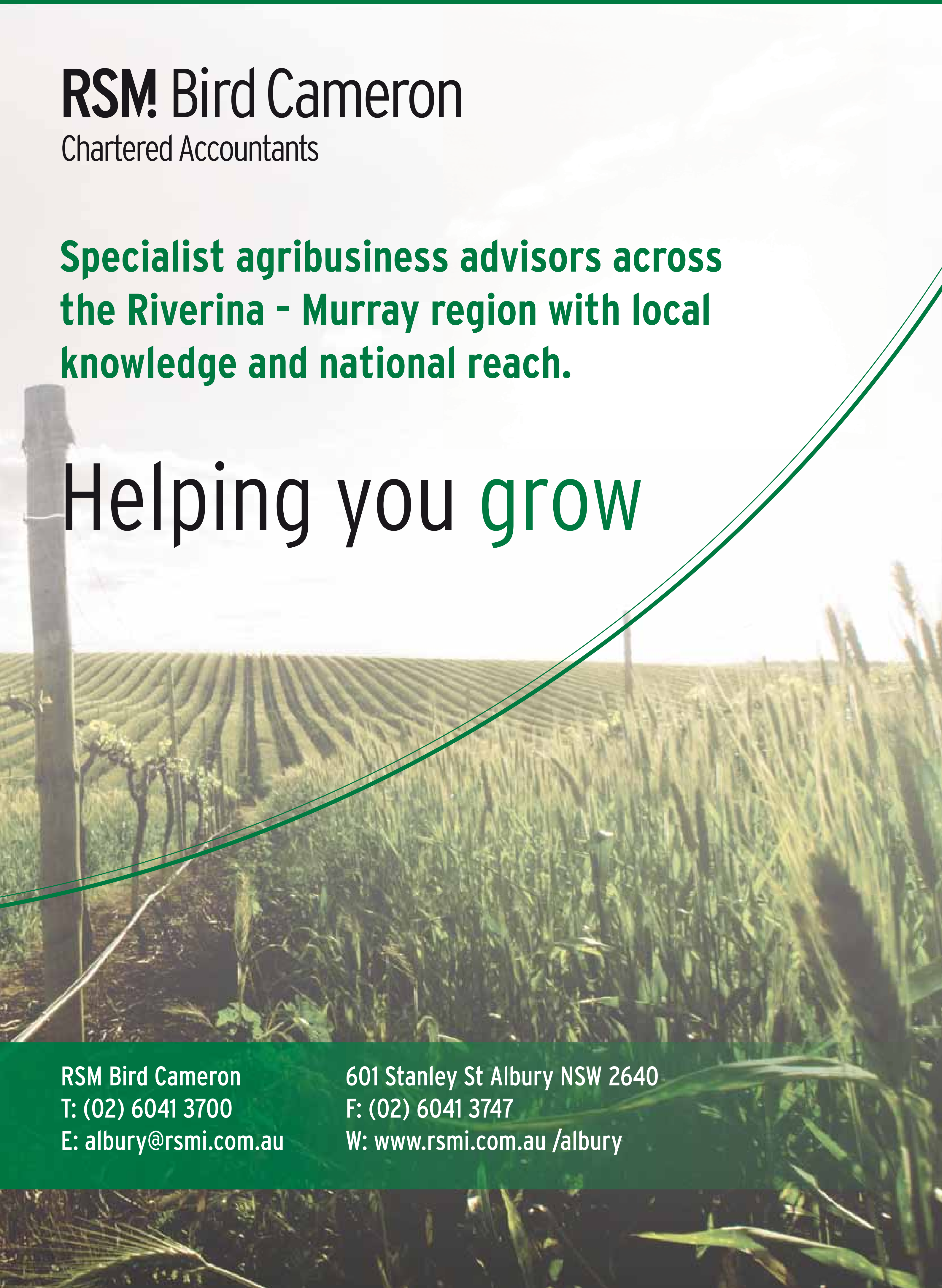
TABLE 1 Example of a replicated trial with four treatments

	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.


RSM Bird Cameron
Chartered Accountants
Specialist agribusiness advisors across the Riverina - Murray region with local knowledge and national reach.
Helping you grow
RSM Bird Cameron
T: (02) 6041 3700
E: albury@rsmi.com.au
601 Stanley St Albury NSW 2640
F: (02) 6041 3747
W: www.rsmi.com.au /albury



A word from the Chairman

Andrew Russell
Glenmoir, Browns Plains

Membership is at the heart of the Riverine Plains Inc success story. Since Riverine Plains first started operating 11 years ago, the membership numbers have steadily increased and it was pleasing to see that 2010 was no exception.

Riverine Plains is all about providing quality and timely information to our farming membership and the 2010 extension program was jam-packed full of field days, seminars and workshops dealing with the ever-changing range of issues facing growers across the Riverine Plains. A particular highlight included the annual Grains Research and Development Corporation (GRDC) update held during February, where we had another record attendance and positive feedback about the day and speakers.

The climatic conditions during 2010 brought a different set of challenges to our members. Sowing proved to be difficult in minimum-till systems because most growers encountered trash-flow issues as a result of heavy 2009 stubbles. This prompted Riverine Plains to host five grower meetings across the districts (at short notice) to bring growers together in the paddock to discuss the successes and failures of sowing. The meetings were a great success with most participants taking away new ideas and information to help manage problems with stubble retention in the future.

Today most growers understand the important role business management plays in running a successful farming enterprise. Riverine Plains Platinum Sponsors NAB and RSM Bird Cameron again helped facilitate our annual Business Update where attendees had the opportunity to listen and participate in a hands-on workshop and learn some new skills to apply to their own farming businesses.

Of course research plays a huge part of the Riverine Plains year and 2010 was no different. Our main project, the GRDC funded *Improved water use efficiency (WUE) in no-till cropping and stubble retention systems in spatially and temporally variable conditions in the Riverine Plains* ran well and the field days were well attended at both sites. We would particularly like to thank Nick Poole, John Seidel as trial manager and the hosting farmers for their support again this year.

We were also involved with the summer cropping WUE project at Dookie and would like to thank the University of Melbourne for their support.

During the middle of the season we hosted our In-season Update at Mulwala, which again was well attended and a great source of pertinent information. The quality and relevance of the information presented at this critical time of year helped make some of those tough decisions a little easier.

During 2010 Riverine Plains implemented some new structural changes to improve the way we run the committee and the roles of the committee members in an attempt to streamline workloads and responsibilities. Most of the recommendations from the initial investigating committee have been implemented with positive results. That said, I feel there is a bit more work to do to keep the group operating at the optimum level. As such, during June 2011 the committee will be participating in an operational workshop to find better ways to achieve the goals we have set ourselves and set out a positive plan for the future.

One of Riverine Plains' greatest strengths is the fact we are independent, free from influence and able to deliver unbiased research and extension. But to do that we need sponsors, and the support we get from our sponsors is simply fantastic, and we would like to take the opportunity to thank them sincerely.

The past 12 months has been somewhat of a rollercoaster in the cropping sector with an anticipated bumper crop largely downgraded after a long, arduous and wet harvest. Something we haven't seen for some time! I suppose the unexpected is what we are coming to expect.

Overall, I feel the year was another great success for Riverine Plains (although a little wet toward the end) with an excellent program and a great response from members. I would like to personally thank our committee of dedicated volunteers, our executive support, contracted staff and Fiona Hart for ensuring that Riverine Plains continues to do the best job possible on behalf of our membership.

Whatever the coming year brings, Riverine Plains will be there to help keep us informed on what is pertinent at the time and to research and facilitate what our members need in the future. That's our goal.

Here's to a smoother ride this season!

2010 — the year in review

Seasonal summary

Janet Walker
NSW DPI, Albury

The 2010 season was one of the wettest years, if not the wettest year, for all areas across the Albury district.

The rain started with good falls during February and March. The start of April was dry, but good sowing rains fell at the end of the month. The widespread April rain was sufficient to sow most crops and good conditions continued into May. A dry period at the end of May delayed sowing of some late crops and slowed growth of some establishing crops.

Winter followed with mild, wet conditions and the region experienced average rainfall from June through to September.

Spring conditions were mild and very wet with flooding in some parts of the district. This was in stark contrast to the dry conditions of previous years.

The wet conditions extended into November and December, severely affecting harvest.

Temperatures for 2010 were generally above average — particularly minimum temperatures. Soil temperatures for the first half of the year to June were also above average, aiding speedy crop establishment and strong pasture growth. Conditions for growth were excellent throughout the season with high yield potentials in crops and pastures. However, the continuing wet conditions affected grain and hay quality at harvest.

Monthly maximum temperatures for 2010 were very close to average, with the exception of December, which was much cooler (see Figure 1). Minimum temperatures were above average throughout the year. The high minimum temperatures led to fewer frosts (see Figure 2) with only one significant frost at the end of September, which caused some crop loss.

The annual rainfall total for Albury was 898mm while 871mm fell in Corowa (see Figures 3 and 4). Rainfall was above average throughout the season, with the district receiving falls in the range of decile 8–9 (see Figures 5 and 6).

The cumulative growing season rainfall for Albury and Corowa was in decile 7 and 8 respectively (see Figures 7 and 8).

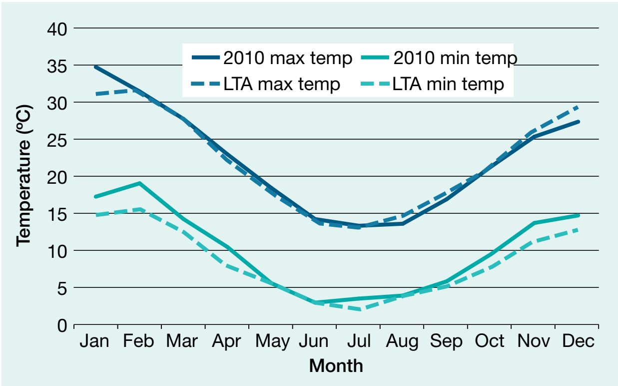


FIGURE 1 Minimum and maximum temperatures for 2010 compared with long-term averages (LTA)

Cropping review

Ideal moisture conditions during late summer and early autumn meant many early-sown grazing oat and triticale crops were well established by April. Because of the dry start to April, these grazing crops were moisture stressed until rain at the end of the month. The good early conditions meant some crops were grazed by early May.

Late April rain provided an ideal opportunity for timely sowing of canola, lupins and early wheats. Seasonal conditions led to increased area of crop, particularly canola, compared with previous drier seasons. An increased number of canola crops were sown early for grazing.

Some of the early-sown cereal crops were eaten out by locusts and had to be re-sown in western areas of the district. Sowing ceased towards the middle of May as moisture dried out. Rain during late May meant sowing was completed with ideal conditions for crop establishment.

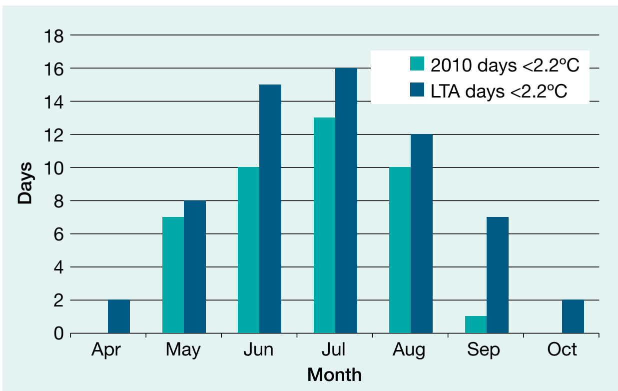


FIGURE 2 Frosts in Albury 2010 compared with long-term averages (LTA)

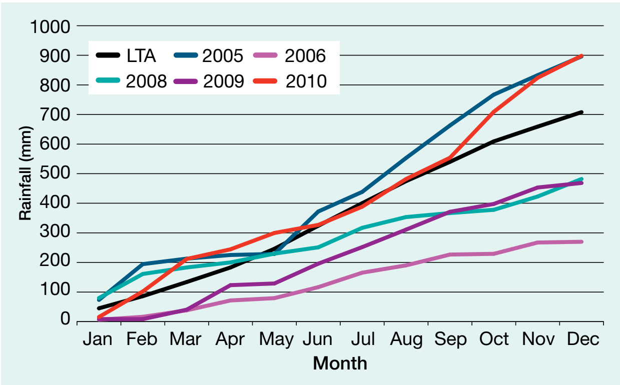


FIGURE 3 Cumulative rainfall Albury

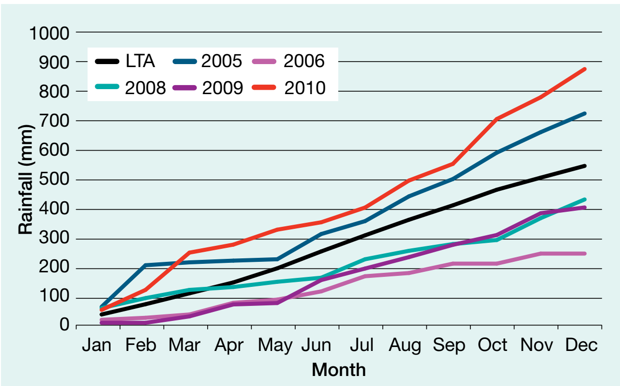


FIGURE 4 Cumulative rainfall Corowa

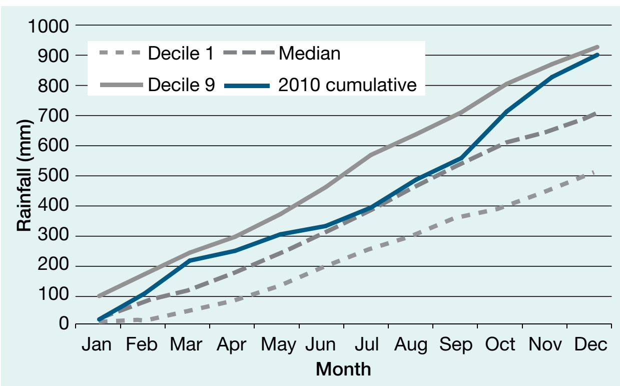


FIGURE 5 Cumulative rainfall at Albury 2010 against decile 1, median and decile 9

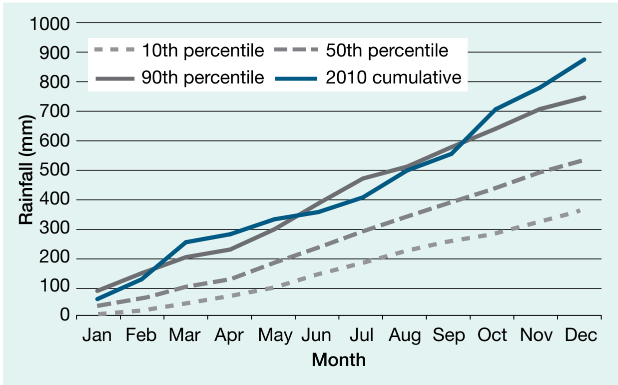


FIGURE 6 Cumulative rainfall Corowa 2010 against 10th, 50th and 90th percentile

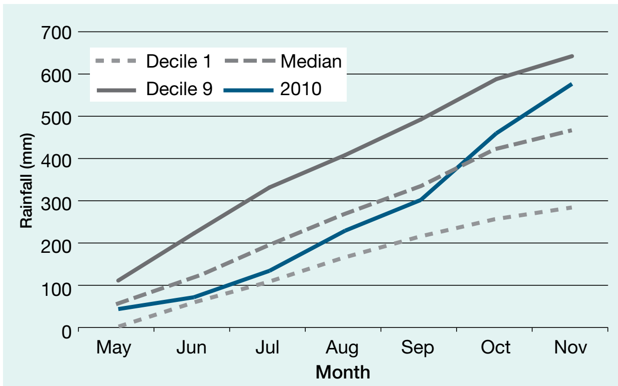


FIGURE 7 Cumulative growing season rainfall at Albury 2010 against decile 1, median and decile 9

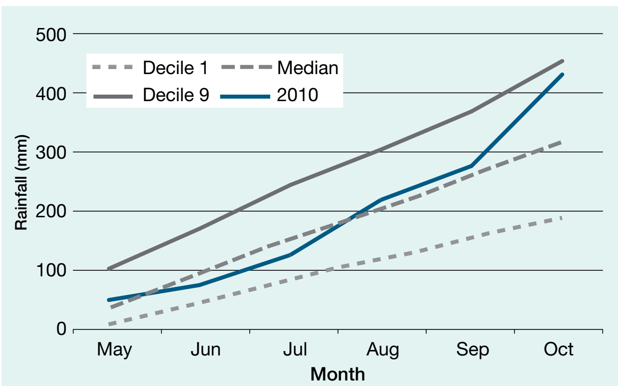


FIGURE 8 Cumulative growing season rainfall at Corowa 2010 against decile 1, median and decile 9

Crops established well, though aphids and mites caused some damage in emerging pastures and crops. The main issue arising from mite damage was the number of crops suffering from viruses (introduced by the mites) later during the season, particularly barley yellow dwarf virus (BYDV) in oat crops.

Crop progress during the growing season was excellent with high yield potentials across the district.

The rainfall continued into early spring with about 5–10% of crops suffering some waterlogging by September. This delayed some topdressing, herbicide and rust control operations. The waterlogged paddocks also lost available nitrogen due to the wet conditions.

With the high yield potential and moisture conditions many growers topdressed crops at higher rates than during previous seasons. However, the continuing wet conditions resulted in some paddocks being too wet to allow traffic, with some topdressing occurring into late spring.

Stripe rust in New South Wales was reported early (June) in the central part of the State, however it was not reported in the Albury district until late July, where it was found in the western areas of the district. Rust was initially found in susceptible crops sown without a seed treatment, particularly in early varieties such as Whistler and Wedgetail. The early rust was caused by the Yr17 and Jackie pathotypes.

Rust was more widespread by August and September with susceptible crops being sprayed two to three times during the season.

The Tobruk rust pathotype found during late 2009 also was reported in some crops. A new rust pathotype, called Yr17–27, was detected on Livingston crops in central NSW. This new pathotype could impact crops during 2011.

Yellow leaf spot (YLS) was also prevalent in crops, with the wet conditions more favourable for severe disease development into spring. Some rust-resistant varieties were sprayed with fungicides for YLS.

Despite the wet conditions, levels of sclerotinia in canola and lupins were not as high as expected. The low levels of inoculum following the previous dry seasons and the dry conditions during late September during petal fall of the canola, meant conditions weren't overly favourable for stem infection.

Frosts on 29 and 30 September caused loss to crops in the Albury district, with most affected crops in the western area of the district. Losses of 5–10% damage were reported, however there were some crops with up to 30% loss. However, some of these crops compensated well for grain loss because of the ideal finishing conditions.

October rainfall was welcomed to finish crops, however for many it was too much of a good thing. Rain caused significant crop losses in the western area of the district, where crops were inundated for more than a week, particularly along the Billabong creek area.

Crop loss to flooding on the eastern side of the district was minimal because water was off crops much faster.

The wind following the very wet conditions also led to a lot of crop lodging, particularly early canola crops and some hybrid canola varieties.

Locusts were expected to threaten crops, as there were large numbers in the north and west of the State, however most crops were mature before locusts became a problem in the Albury district.

The continued wet conditions proved to be the greatest cause of profit loss in what had shaped up to be an excellent season.

The cool conditions delayed crop development with windrowing of canola at least 10 days later than in previous seasons. Canola crops had ideal cool conditions for finishing and this led to high yields and oil contents. This was true for crops harvested before the wet conditions set in, but later-harvested crop yields were lower due to shattering and the seed was poorer quality. The area harvested was also reduced due to areas severely affected by flood and waterlogging damage. Average canola yields for the district were 1.5t/ha.

The cereal crop harvest experienced similar problems to the canola harvest. Not all crops were harvested due to flood conditions and severe waterlogging. The better-quality grain was from crops harvested early in the western parts of the district — mainly barley. Although there was a high yield potential in many crops, later-harvested crops again had poor quality grain. Most of this grain was feed quality with a lot of shot and sprung grain and low falling numbers. Grain protein in many cereal crops was high.

Harvest was protracted due to the wet conditions and continued well into January.

While there were some crops with higher yields, district averages for Albury were 2.7t/ha for wheat and 3t/ha for barley.

Lupin yields were better than average, at 2.5t/ha or higher. Some grain was stained due to wet conditions, which was an issue for Albus crops.



Pasture production

Pasture growth was excellent following the rain throughout the season. There was strong pasture and weed growth during summer, which kept stock going without reliance on supplementary feeding. Lucerne pastures proved valuable during this period, because of their ability to react to summer rainfall.

Early growth and establishment of Paterson's curse and barley grass made control difficult later in the season. Pasture growth continued, though the early wet conditions did lead to leaf rust in phalaris and heliothus in lucerne.

Early-sown cereals provided good grazing and the mild conditions meant there was adequate winter feed. The excellent pasture growth continued well into spring.

There were a few problems with inability to control broadleaf weeds due to wet conditions, with weeds too advanced for effective capeweed or Paterson's curse control.

The wet conditions also caused problems with hay and silage production, with wet paddocks delaying cutting, which led to lower-quality forage. Some silage made very early during late September was the best quality, as it escaped the wet conditions.

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.

CONTACT

Janet Walker
NSW DPI, Albury
T: (02) 6051 7704
E: janet.walker@industry.nsw.gov.au

Performance of wheat (after canola) 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, New Zealand
[2] Agricultural Research Services

Key points

- With 570mm growing season rainfall (GSR) 2010 wheat yields were more than double those experienced during 2009 in the same rotation position (wheat after canola).
- Yield drop-off associated with the wide row spacing (37.5cm) was almost identical to 2009 results, with a 12% yield reduction compared with the narrow spacing (22.5cm).
- The narrow row spacing was significantly higher yielding than the 30cm row spacing, where there was no yield difference in 2009.
- Nitrogen off-take in the grain and straw at harvest was 10% higher with the narrow row spacing, however the harvest index was almost identical (about 38%) to wide rows.
- Although there was a 0.2t/ha yield advantage with the disc opener over the tine, it was not significant, however it was identical to the yield difference observed in 2009.
- Increasing canola stubble loading (extra 10t/ha) post emergence significantly reduced yield compared with the commercial canola stubble loading in the paddock.

Location: Coreen, NSW

Rainfall:
Annual: 835mm
GSR: 570mm (April–mid-November)

Soil:
Type: Clay loam
pH (H_20): 5.9
pH ($CaCl_2$): 4.9

Sowing information:
Variety: Gladius, wheat
Sowing date: 27 May 2010
Sowing rate: 85kg/ha
Fertiliser: MAP + Intake
Seeding equipment: Janke tine with Janke press wheel, single disc opener
Treatments: Disc, tine, tine + extra stubble

Row spacing: 22.5cm, 30cm and 37.5cm

Paddock history:
2009 — canola
2008 — triticale

Plot size: 44m x 3m

Replicates: 4 (disc), 6 (tine) and 4 (tine + extra stubble)

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 in two no-till rotations.

Method

A replicated experiment was established to test the effect of a range of drill openers and row spacings in two no-till wheat rotations. In this trial, the crop was first wheat after canola.

Crop stubble from the previous canola crop trial (see *Research for the Riverine Plains 2010* pages 10–13) was chopped and spread at right angles to the direction of plots.

Results

Crop establishment

The establishment of wheat sown at the 22.5cm row spacing was significantly ($p<0.001$) better than crops sown at 30cm, which in turn was significantly superior to the 37.5cm row spacing.

It is still unclear why, at such early stages of establishment (one-leaf to three-leaf), the extra competition within the row at the wider row spacing should reduce establishment. However the results are consistent with those seen from last season's trial at this site (see Table 1 and Figure 1).

Disc openers resulted in significantly better establishment ($p<0.001$) than tine openers in this first wheat after canola crop (see Figure 2). While differences between establishment figures were small, the result is consistent with a trend seen in the equivalent rotation position last season.

Extra canola stubble added after emergence on 16 June had a small negative effect on establishment when assessed 20 days later at the three-leaf stage.

The effect of row spacing was similar across drill openers and there was no significant interaction between these two factors (see Figure 3).

Dry matter production

i) Row spacing

Wheat crops established at the 22.5cm row spacing produced significantly more dry matter (DM) than crops established at the 30cm and 37.5cm row spacings when assessed from the start of stem elongation (GS31) through until harvest (GS99) (see Figure 4). Though there was a consistent trend for the 30cm row

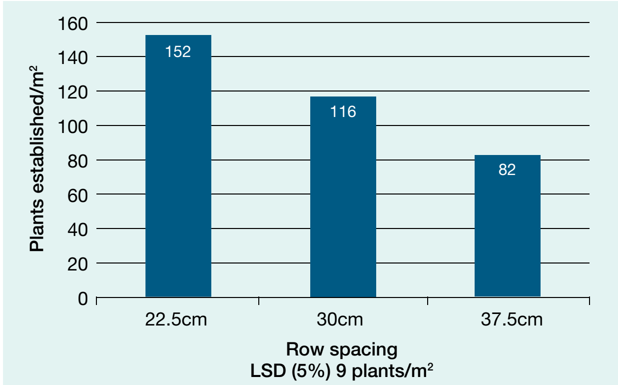


FIGURE 1 Influence of row spacing on plant establishment, at the three-leaves-unfolded stage (GS13) 39 days after sowing

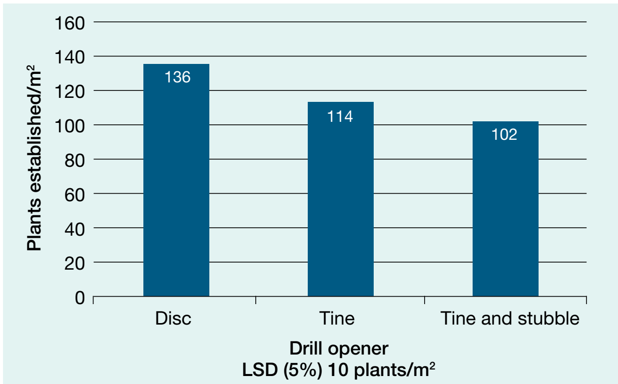


FIGURE 2 Influence of drill opener and additional stubble on crop establishment at the three-leaves-unfolded stage (GS13) 39 days after sowing

TABLE 1 Plant establishment at the coleoptile emerging to first-leaf-unfolded stages (GS10–11) and the three-leaves-unfolded stage (GS13) assessed 22 and 39 days after sowing

Row spacing (cm)	Drill opener[1] Plant establishment (plants/m²)							
	18 June 2010				5 July 2010			
	Disc	Tine	Tine + stubble[2]	Mean	Disc	Tine	Tine + stubble[2]	Mean
22.5	114	98	96	**103**	178	147	134	**153**
30.0	92	76	71	**80**	132	116	99	**116**
37.5	69	56	49	**58**	99	78	74	**84**
Mean	**92**	**77**	**72**		**136**	**114**	**102**	
LSD (row spacing)	5				9			
LSD (drill opener)	5				10			
LSD (disc) (tine)	10	7			18	13		
LSD (disc vs tine)	8				14			
Interactions — drill opener x row spacing					ns			

[1] Tine treatments had six replicates compared with four for the disc treatment and tine plus stubble
[2] Extra canola stubble (10t/ha) was added on emergence of wheat at GS11

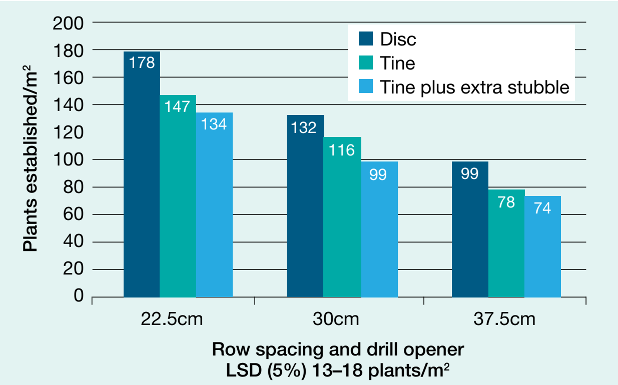


FIGURE 3 Influence of row spacing and opener method on plant establishment at three-leaves-unfolded stage (GS13) 39 days after sowing

spacing to be superior to the 37.5cm row spacing, this was only statistically significant during stem elongation (GS31 and GS39).

ii) Drill openers

The disc opener produced slightly higher DM than the tine opener following significantly better plant establishment during autumn. This advantage was greatest and most significant at flag leaf (GS39) and early grain fill (GS71).

This DM advantage had been eroded by harvest time so that there was no significant difference in DM between the tine and disc opener (p = 0.14).

Where the extra stubble loading was applied post emergence to the tine treatment, there was no effect on DM production, even though there appeared to be a visual reduction in DM from field observations (see Figure 5).

There was no significant interaction between row spacing and drill opener for total DM at harvest. Where extra stubble had been added to the tine treatment, DM trended to be higher at harvest (see Figure 6) than at early grain fill.

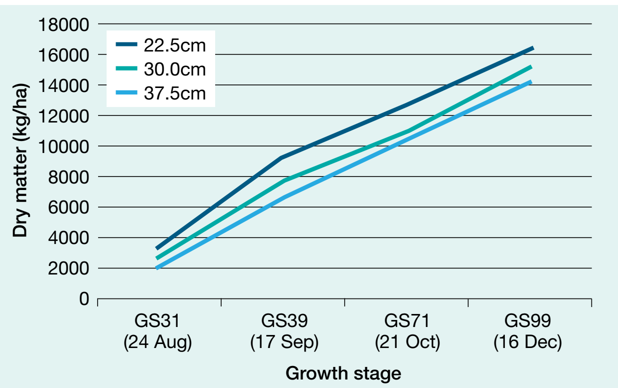


FIGURE 4 Influence of row spacing on dry matter production*
* Mean of both drill openers (24 August–16 December 2010)

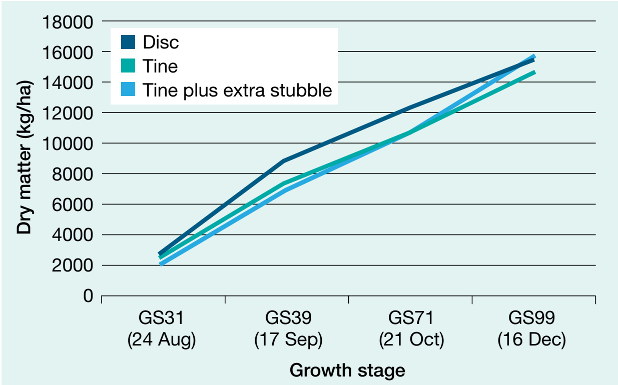


FIGURE 5 Influence of opener on dry matter production*
* Mean of three row spacings (24 August–16 December 2010)

Crop structure

Differences in plant establishment followed through to produce significant differences in both tiller numbers at first node (GS31) and head numbers at harvest (see Figure 7).

Yield (t/ha) and grain protein (%)

i) Yield

Row spacing produced significant yield differences (p = 0.001). The 22.5cm row spacing yielded significantly

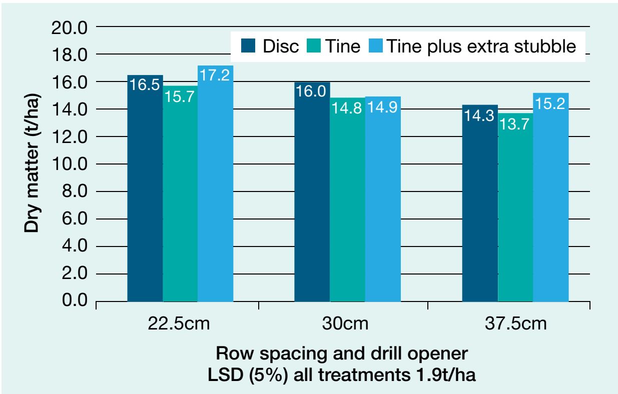


FIGURE 6 Influence of row spacing and drill opener on dry matter production at harvest*
* GS99–16 December 2010

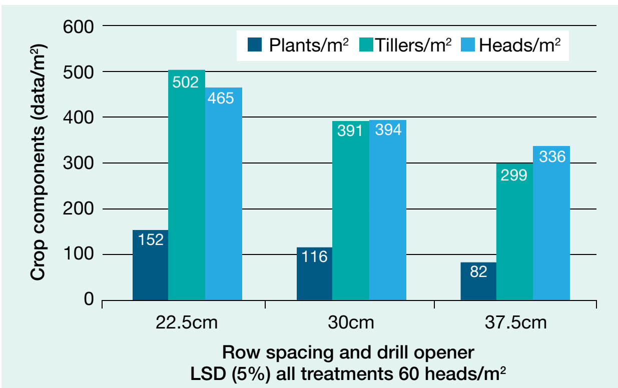


FIGURE 7 Influence of row spacing on crop structure



more than 30cm and 37.5cm row spacings. The reduction in yield compared with the 22.5cm row spacing was 7% for the 30cm row spacing and 12% at the 37.5cm spacing (see Figure 8).

In an equivalent trial (same point in rotation) at this site in 2009, the yields were less than 50% of those recorded in 2010. However the percentage drop in output at the 37.5cm row spacing was almost identical at 13%, though there was no significant difference between 22.5cm and 30cm spacings in that lower-yielding season.

There was a 0.21t/ha yield advantage in favour of the disc opener in this trial (though not statistically significant) — a result almost identical to that produced in the same comparison during 2009. Where stubble loading was increased with the tine treatment (10t/ha of canola stubble added at crop emergence), yield was significantly lower than the equivalent tine treatment having only the field stubble loading (3–3.5t/ha) (see Figure 9).

There was no significant interaction between row spacing and the drill opener, therefore the 22.5cm row spacing was significantly better than other row spacings, irrespective of opener and stubble loading (see Figure 10).

The disc opener combined with the 22.5cm row spacing, showed a trend to being the highest yielding combination but it was not significantly superior to the other drill opening stubble loading combinations tested at the same row spacing.

ii) Protein (%) and nitrogen off-take

Grain protein content gave an inverse relationship with yield, such that the higher the yield the lower the protein (see Figure 11). The nitrogen (N) content of the grain and straw at harvest showed higher nitrogen off-takes with treatments that produced the highest yields and biomass — at the narrowest row spacing (see Figure 12).

The 22.5cm row spacing removed, on average, 200kg/ha of nitrogen to produce yields of 6.2t/ha compared with 180kg/ha nitrogen off-take at the widest row spacing, which yielded 5.5t/ha.

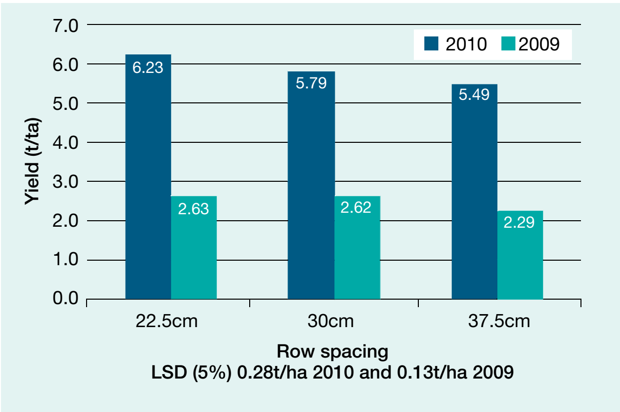


FIGURE 8 Influence of row spacing on yield during 2009 and 2010*

* Mean of both drill openers.

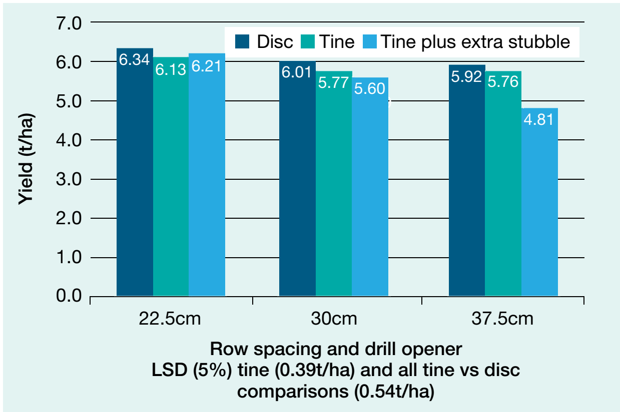


FIGURE 10 Influence of row spacing and drill opener on yield

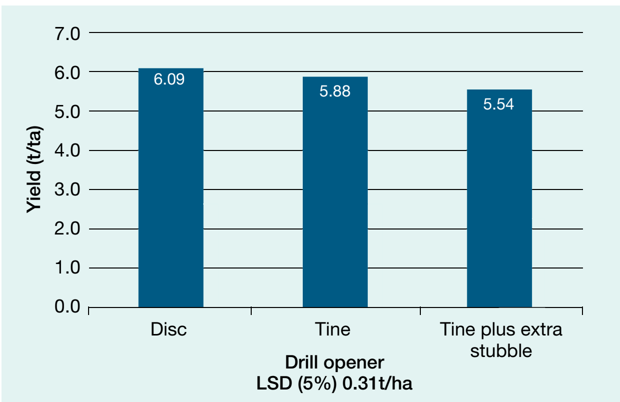


FIGURE 9 Influence of drill openers and extra stubble on yield*

* Mean of three row spacings

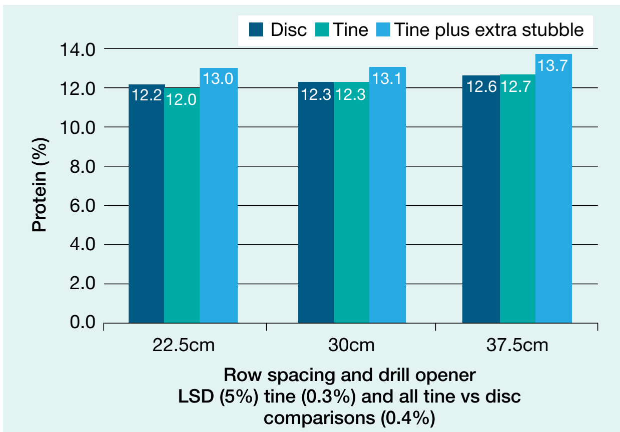


FIGURE 11 Influence of row spacing and drill opener on protein

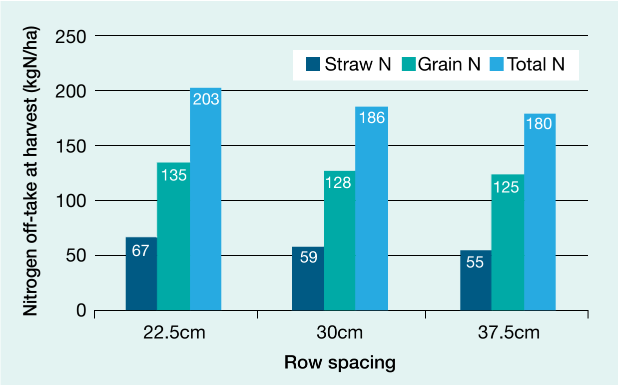


FIGURE 12 Influence of row spacing on nitrogen off-take in straw or chaff and grain

Observations and comments

There was little difference in harvest index (37.8–38.1%) due to row spacing. As biomass increased with a narrower row spacing, so did grain yield.

Slightly higher WUE was recorded with the narrower row spacing, resulting from better use of water available to the crop. Losses due to evaporation (and possibly drainage) were calculated to have been lower with the narrow row spacing than those for the wider row spacings (see Table 2).

SPONSORS

This trial was carried out as part of the Riverine Plains Inc GRDC-funded project *Improved WUE in no-till cropping and stubble retention systems in spatially and temporally variable conditions in the Riverine Plains* (RPI00007).

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

CONTACT

Nick Poole
Foundation for Arable Research, New Zealand
E: poolen@far.org.nz

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

Row spacing (cm)	Biomass (kg/ha)	Yield (kg/ha)	HI (%)	WUE [1] (kg/m)	Transpiration [2] (mm)	Evaporation [3] (mm)	TE [4] (kg/mm)
22.5	16,466	6226	37.8	10.9	299	271	20.8
30.0	15,263	5795	38.0	10.2	278	292	20.9
37.5	14,402	5494	38.1	9.6	262	308	21.0

[1] Based on 570mm of GSR (April–mid-November) includes 35% fallow efficiency for January, February and March rainfall (160mm) 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 biomass/ha.mm transpired
[3] Difference between water transpiration through the plant and GSR (mm)
[4] Transpiration efficiency based on kg/ha grain produced per mm of water transpired through the plant
* Mean of both openers and additional stubble treatment



Performance of second wheat (wheat on wheat) after canola 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, New Zealand
[2] Agricultural Research Services

Key points

- Wheat on wheat (following canola) yielded 4.91t/ha, almost 1t/ha less than the neighbouring first wheat trial after canola (same cultivar, sowing date and inputs), which yielded 5.84t/ha.
- There was no yield drop-off associated with wider row spacings (30cm and 37.5cm) in this wheat-on-wheat situation.
- Results indicate the higher biomass observed with the narrower row spacing did not translate to grain yield.
- There were no significant effects of the drill opener (disc vs tine) on dry matter (DM), crop structure or yield.
- 165–175kg/ha of nitrogen (N) was removed in above-ground biomass (straw and grain) with wheat on wheat.
- Nitrogen off-take in the grain (protein) at harvest was unaffected by row spacing or drill opener, however there was evidence the narrow row spacing removed slightly more nitrogen in the straw due to higher DM.
- Water use efficiency was similar among the treatments, though there was evidence of slightly higher water losses from the soil with the wider row spacing.

Location: Coreen, NSW

Rainfall:
Annual: 835mm
GSR: 570mm (April–mid-November)

Soil:
Type: Clay loam
pH (H_20): 5.9
pH ($CaCl_2$): 4.9

Sowing information:
Variety: Gladius, wheat
Sowing date: 27 May 2010
Sowing rate: 85kg/ha
Sowing fertiliser: MAP + Intake
Sowing equipment: Janke tine and press wheel. Single disc opener

Row spacing: 22.5cm, 30cm and 37.5cm

Paddock history:
2009 — wheat
2008 — canola

Plot size: 44m x 3m

Replicates: 4 (disc) and 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 for a second wheat (wheat on wheat) after canola in a no-till rotation. Results for an equivalent trial evaluating first wheat following canola (also run during 2010) can be found on pages 6–10.

Method

A replicated experiment was established to test the effect of a range of drill openers and row spacings in a second wheat crop (wheat on wheat) after canola.

Crop stubble from the previous first wheat crop trial (see *Research for the Riverine Plains 2010* pages 14–17) was chopped and spread at right angles to the direction of plots.

Results

Crop establishment

The establishment of wheat into wheat stubble from the previous crop resulted in the narrow (22.5cm) row spacing giving significantly ($p<0.001$) better establishment than crops sown at 30cm, which in turn were significantly superior to 37.5cm. This result was identical to the neighbouring first wheat trial after canola (see Table 1 and Figure 1).

Disc openers resulted in significantly better establishment ($p<0.02$) than tine openers in this wheat-on-wheat crop (see Figure 2). The results are similar to those observed in the first wheat trial at the same site. While the differences were statistically significant, the actual differences in plants established was small (less than 15 plants/m²).

The effect of row spacing was similar across both drill openers and there was no significant interaction between these two factors, however the differences between openers was very small at the widest row spacing (see Figure 3).

Dry matter production

i) Row spacing

Second wheat (wheat on wheat) crops established at 22.5cm row spacing produced significantly more DM than both the wider row spacings at the start of stem elongation (GS31). Thereafter, the 22.5cm spacing was only significantly superior to the widest spacing (37.5cm) (see Figure 4). The 30cm row spacing produced significantly more biomass than the 37.5cm spacing, but showed no significant difference for the narrow spacing (22.5cm) from flag leaf emergence onwards.

TABLE 1 Plant establishment at the coleoptile emerging to first-leaf-unfolded stages (GS10–11) and three-leaves-unfolded stage (GS13) assessed 22 and 39 days after sowing

Row spacing (cm)	Drill opener[1] Plant establishment (plants/m²)					
	18 June 2010			5 July 2010		
	Disc	Tine	Mean	Disc	Tine	Mean
22.5	120	114	**117**	170	147	**158**
30.0	100	91	**96**	133	121	**127**
37.5	77	72	**74**	98	96	**97**
Mean	**99**	**92**		**134**	**121**	
LSD (row spacing)	8			11		
LSD (drill opener)	6			9		
LSD (disc) (tine)	13	9		19	13	
LSD (disc vs tine)	11			16		
Interactions — drill opener x row spacing				ns		

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

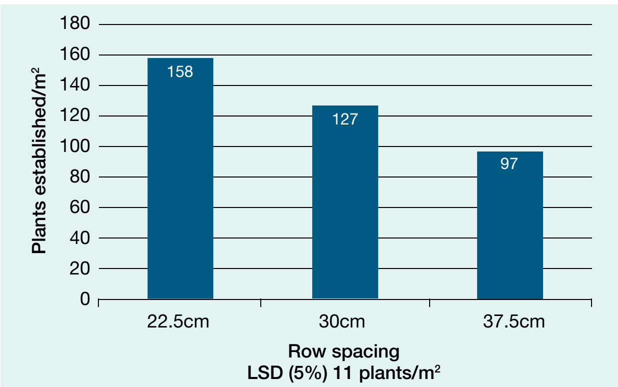


FIGURE 1 Influence of row spacing on crop establishment, at the three-leaves-unfolded stage (GS13) 39 days after sowing

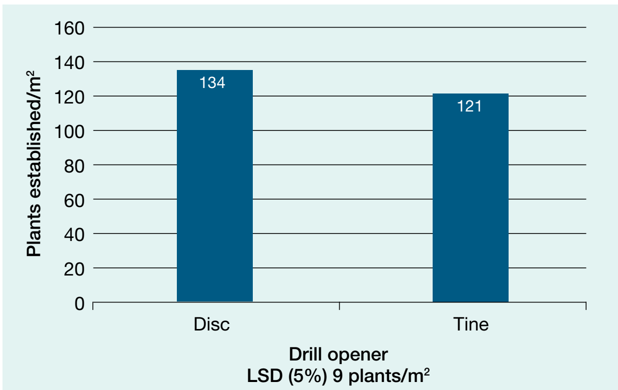


FIGURE 2 Influence of drill opener on crop establishment, at the three-leaves-unfolded stage (GS13) 39 days after sowing

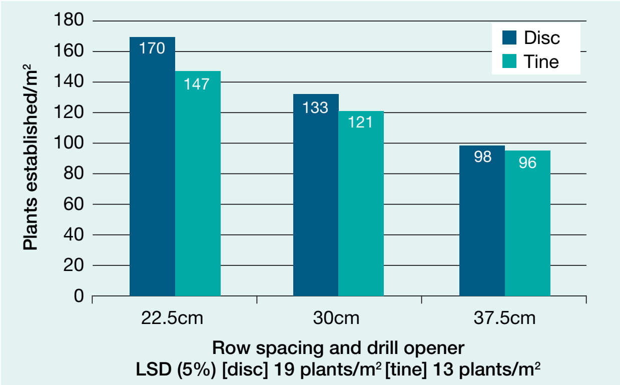


FIGURE 3 Influence of row spacing and drill opener method on crop establishment, at the three-leaves-unfolded stage (GS13) 39 days after sowing

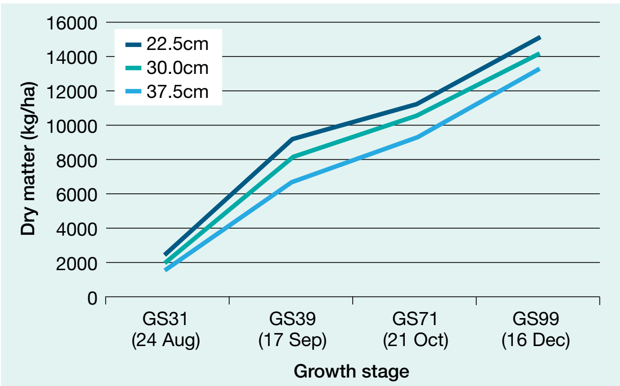


FIGURE 4 Influence of row spacing on dry matter production*
*Mean of both drill openers (24 August–16 December 2010)

ii) Drill openers

At the start of stem elongation (GS31), the disc-established plots had produced more DM than the tine-established plots, a result that was probably linked to the slightly higher plant population with the disc treatments (see Figure 5). However from flag leaf emergence (GS39) onwards there was no difference in DM production between the two different drill openers.

There was no significant interaction between row spacing and drill opener on harvest DM (p = 0.29), even though there appeared to be a trend to slightly higher harvest DM for the tine treatments at 30 and 37cm (see Figure 6).

Crop structure

Higher plant populations (160 plants/m^2) resulting from the narrower row spacing resulted in the highest tiller populations, about 425 tillers/m^2. The lower plant population resulting from the wider row spacing produced, on average, 2.9 tillers/plant compared with 2.7 tillers/plant where higher plant populations established with the narrow row spacing (see Figure 7).

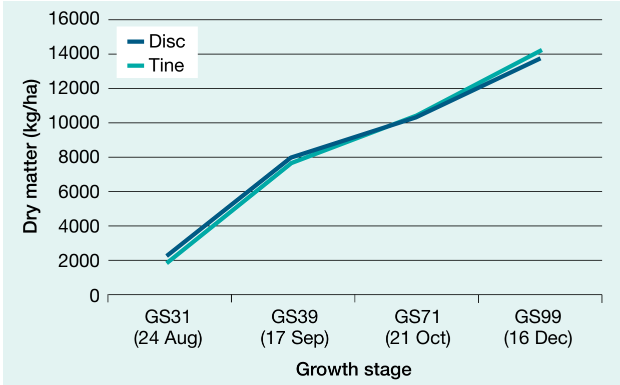


FIGURE 5 Influence of opener on dry matter production*
*Mean of three row spacings (24 August–16 December 2010)

Resultant head numbers revealed little tiller loss between GS31 and harvest, with significantly more heads/m^2 in the 22.5cm and 30cm row spacing treatments than the 37.5cm spacing.

There were no differences in crop structure between disc and tine treatments.

Yield (t/ha) and grain protein (%)

i) Yield

The trial yielded 4.91t/ha, about 1t/ha less than the identical first wheat after canola trial (same cultivar, sowing date and inputs) less than 30m away, which yielded 5.84t/ha. Despite all the same trends being exhibited in establishment and for DM data, as for the wheat following canola trial, there was no significant difference in yield between any of the treatments (p = 0.3). The results indicated that the higher biomass in this wheat-on-wheat rotation position did not translate to grain yield (as occurred in the first wheat trial at the same site). As such, the harvest index (proportion of biomass partitioned as grain) was lower at the narrower row spacing. The results are also in

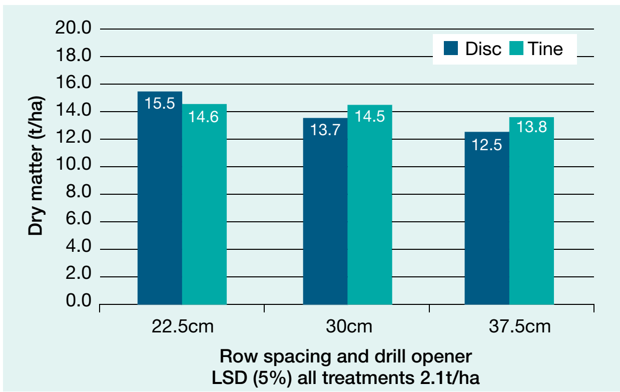


FIGURE 6 Influence of row spacing and drill opener on dry matter production at harvest*
* GS99 — 16 December 2010

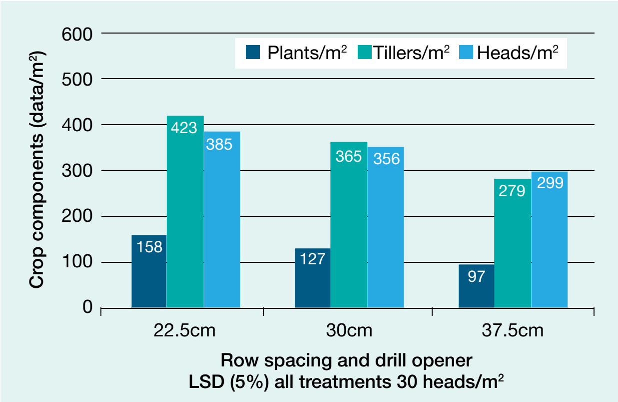


FIGURE 7 Influence of row spacing on crop structure

contrast to the preceding trial carried out during 2009, when wheat after canola was tested (see Figure 8).

Both drill openers produced near identical yields 4.90t/ha (disc) and 4.91t/ha (tine) when averaged across the different row spacings (see Figure 9). Again, there was no significant interaction between drill opener and row spacing, though as was the case with harvest DM, there appeared to be a slight yield disadvantage with the disc opener at 37.5cm (see Figure 10).

ii. Protein (%) and nitrogen off-take

Despite the lack of yield difference, grain protein content was slightly higher at the widest row spacing ($p = 0.04$) (see Figure 11). The nitrogen content of the grain and straw at harvest illustrated only slight differences in total nitrogen off-take, 175kg/ha of nitrogen at the narrower row spacing and 165kg/ha at the widest row spacing (see Figure 12). This difference was the result of greater nitrogen off-take in straw/chaff at the narrow row spacing, since nitrogen off-take in the grain was identical between the narrowest and widest row spacing (108 kg/ha of nitrogen). Comparing the two trials side by side, first wheat after canola produced an average of 5.84t/ha with 190kg/ha of nitrogen off-take, which equated to 32kg of nitrogen per tonne of production. In the second wheat after canola (wheat on wheat) the average trial yield was 4.91t/ha with 170kg/ha nitrogen off-take, which equated to 34.5kg of nitrogen per tonne of production.

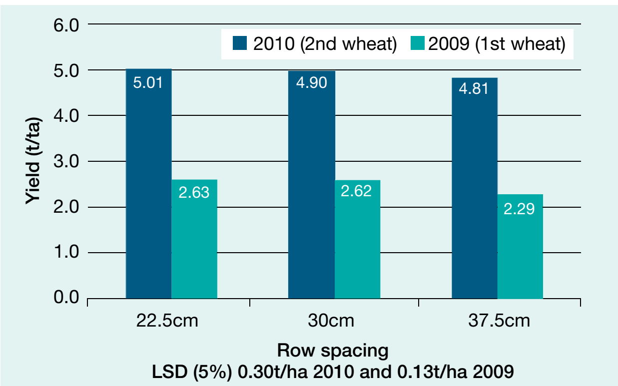


FIGURE 8 Influence of row spacing on yield during 2009 and 2010*

*Mean of both drill openers

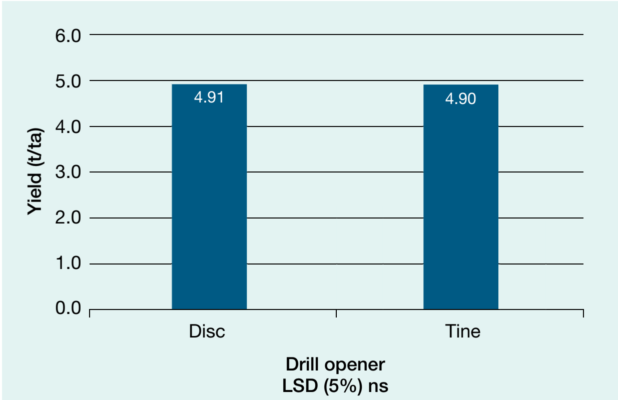


FIGURE 9 Influence of drill openers on yield*

*Mean of three row spacings

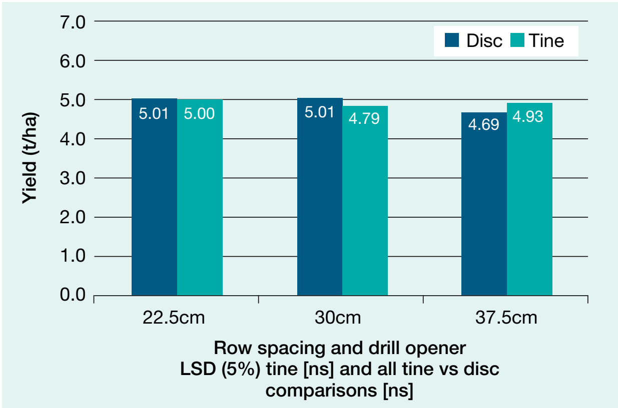


FIGURE 10 Influence of row spacing and drill opener on yield

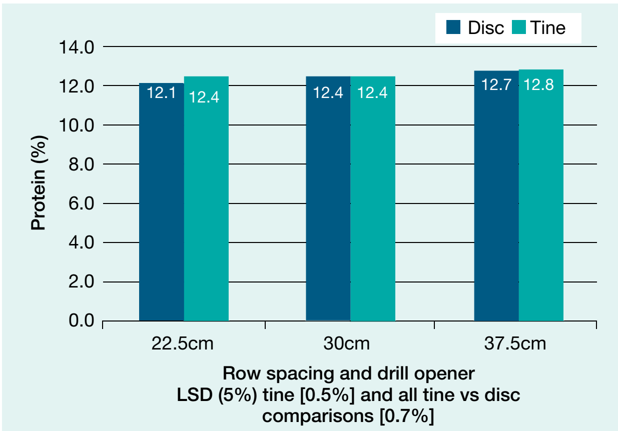


FIGURE 11 Influence of row spacing and drill opener on protein

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

Row spacing (cm)	Biomass (kg/ha)	Yield (kg/ha)	HI (%)	WUE [1] (kg/mm)	Transpiration [2] (mm)	Evaporation [3] (mm)	TE [4] (mm)
22.5	15038	5072	33.7	8.9	273	297	18.6
30.0	14118	4902	34.7	8.6	257	313	19.1
37.5	13181	4806	36.5	8.4	240	330	20.1

[1] Based on 570mm of GSR (April–mid-November) includes 35% fallow efficiency for January, February and March rainfall (160mm) 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 biomass/ha.mm transpired
[3] Difference between transpiration through the plant and GSR (mm)
[4] Transpiration efficiency based on kg/ha grain produced per mm of water transpired through the plant
* Mean of both openers

Observations and comments

Despite a lower harvest index and transpiration efficiency with the narrow row spacing, overall, the crop had slightly higher WUE (see Table 2). This was linked to better use of water available to the crop since it was calculated there was less evaporation/drainage at this spacing compared with the wide row spacing.

The DM harvest index (proportion of biomass partitioned as grain) was lower with narrower row spacing than wider row spacing.

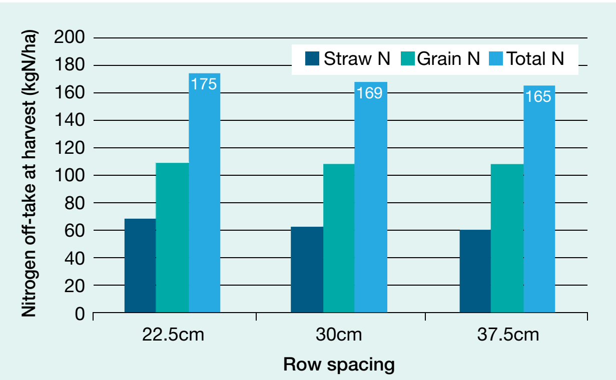


FIGURE 12 Influence of row spacing on nitrogen off-take in straw or chaff and grain

One possible explanation for the failure of the narrower row spacing to convert more biomass into more grain could have been greater root disease pressures in this wheat-on-wheat situation. Closer proximity of narrower rows to previous wheat stubble may have predisposed these treatments to greater infection, however at this stage this cannot be proven.

SPONSORS

This trial was carried out as part of the Riverine Plains Inc GRDC-funded project *Improved WUE in no-till cropping and stubble retention systems in spatially and temporally variable conditions in the Riverine Plains* (RPI00007).

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

CONTACT

Nick Poole
Foundation for Arable Research,
New Zealand
E: poolen@far.org.nz

Performance of 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, New Zealand
[2] Agricultural Research Services

Key points

- With 537mm growing season rainfall (GSR) (April–mid-November) wheat yields following faba beans were 2.2t/ha higher than those experienced in 2009 (5.06t/ha vs 2.86t/ha).
- The yield reduction moving from a narrow row spacing (22.5cm) to wide (37.5cm) was 12% (0.64t/ha), compared with 16% (0.49t/ha) in 2009.
- Yields were significantly higher on the narrow row spacing compared with the 30cm and wide row spacings, between which there was no difference.
- This contrasted with 2009 results where there was no yield disadvantage at 30cm compared with 22.5cm at lower yields in wheat on wheat.
- Nitrogen (N) off-take in harvested grain was nearly 13% higher with the narrow row spacing compared with the widest row spacing, however further analysis is required to determine if the nitrogen off-take of the whole plant was different, or whether nitrogen was partitioned differently between straw and grain.
- There was no difference in yield between the tine and disc opener when the three row spacings were averaged.
- Evidence suggests that at a row spacing of 30cm, the disc was inferior to the tine — a result that correlates to earlier establishment scores.

Location: Bungeet, VIC

Rainfall:
Annual: 925mm
GSR: 537mm

Soil:
Type: Loam over clay, Wattville No. 205
pH (H_2O): 6.74

Sowing information:
Variety: Livingston, wheat
Sowing date: 8 June 2010
Sowing rate: 85kg/ha
Fertiliser: MAP + Intake 85kg/ha
Seeding equipment: Janke tine with Janke press wheel. Single disc opener

Row spacing: 22.5cm, 30cm and 37.5cm

Paddock history:
2009 — faba beans
2008 — wheat

Plot size: 44m x 3m

Replicates: 4 (disc and 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 in a first wheat situation following a commercial crop of faba beans.

Method

A replicated experiment was established to test the effect of a range of drill openers and row spacings in two no-till wheat rotations. In this trial the crop was first wheat after faba beans.

Crop stubble from the previous faba bean crop was chopped and spread at right angles to the direction of plots.



Results

Crop establishment

The establishment of wheat sown at a 22.5cm row spacing was significantly (p = <0.001) better than crops sown at 30cm, which in turn was superior to a 37.5cm row spacing (see Table 1 and Figure 1). These results were identical to those observed in 2009.

At very early emergence (early first leaf), the disc opener produced significantly more plants/m^2 than the tine, however by the three-leaf stage (GS13) this difference was no longer apparent (see Figure 2). This indicates slightly faster emergence with the disc, which may have been related to sowing depth.

The influence of the drill opener was not the same across the different row spacings, with evidence that at the 30cm row spacing the tine opener was statistically superior to the disc, while at other row spacings there was no significant difference in establishment (see Figure 3).

Crop structure

Differences in plant establishment followed through to produce significant differences in both tiller numbers at early stem elongation (GS30) and final head numbers at maturity (see Figure 4).

With the wider row spacings there was noticeably little tiller death, since final head number and tiller numbers are very similar, though final head number was still greater with the narrower row spacing.

Yield (t/ha) and grain protein (%)

i) Yield

Row spacing produced significant differences in yield (p = 0.001). The 22.5cm row spacing was significantly higher yielding than the 30cm and 37.5cm row spacings, between which there was no yield difference.

The yield reduction that occurred when row width increased from 22.5cm to 30cm was 9% in this first wheat following faba beans rotation position.

TABLE 1 Plant establishment at coleoptile emerging to first-leaf-unfolded stage (GS10–11) and three-leaves-unfolded stage (GS13) assessed 16 and 37 days after sowing

Row spacing (cm)	Drill opener[1] Plant establishment (plants/m^2)					
	24 June 2010			15 July 2010		
	Disc	Tine	Mean	Disc	Tine	Mean
22.5cm	134	92	**113**	280	271	**276**
30.0cm	92	65	**79**	198	236	**217**
37.5cm	92	54	**73**	169	154	**162**
Mean	**106**	**70**		**216**	**220**	
LSD [row spacing]	37			19		
LSD [drill opener]	14			16		
LSD [row x opener]	25			27		

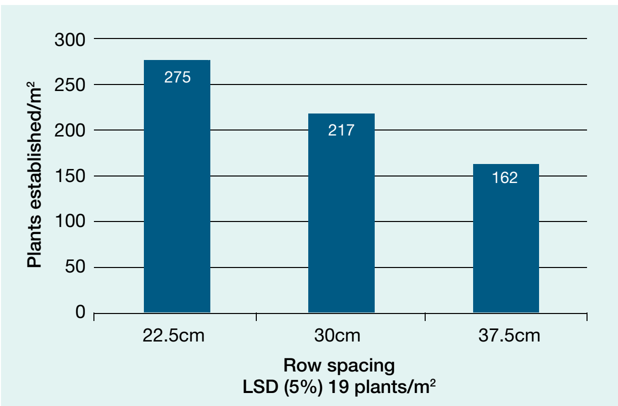


FIGURE 1 Influence of row spacing on plant establishment, at the three-leaves-unfolded stage (GS13), 37 days after sowing

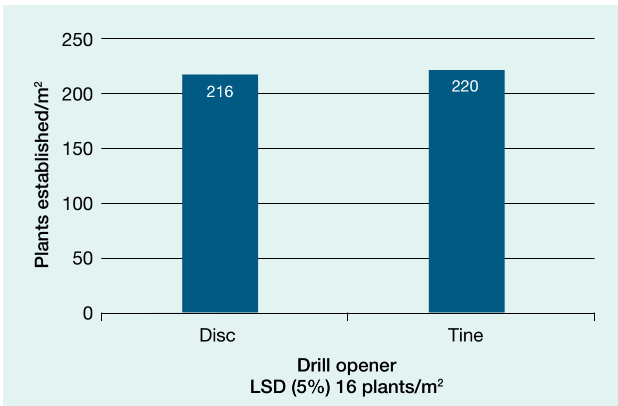


FIGURE 2 Influence of drill opener on crop establishment at the three-leaves-unfolded stage (GS13), 37 days after sowing

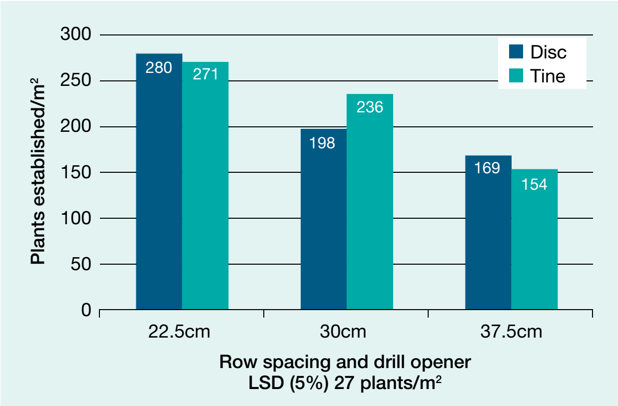


FIGURE 3 Influence of row spacing and opener method on plant establishment at the three-leaves-unfolded stage (GS13), 37 days after sowing

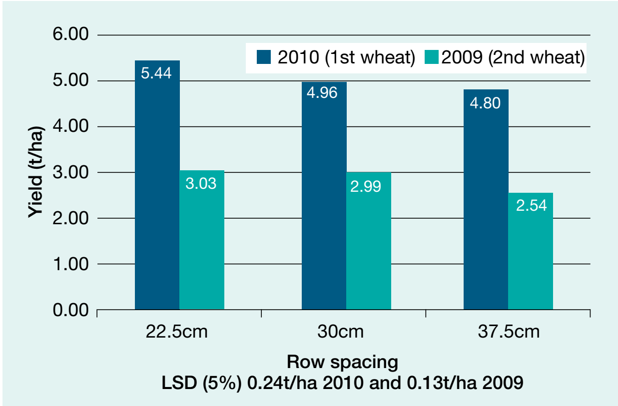


FIGURE 5 Influence of row spacing on yield *
*Mean of both drill openers. 2009 data is taken from wheat-on-wheat trial run in the same paddock but different rotation position

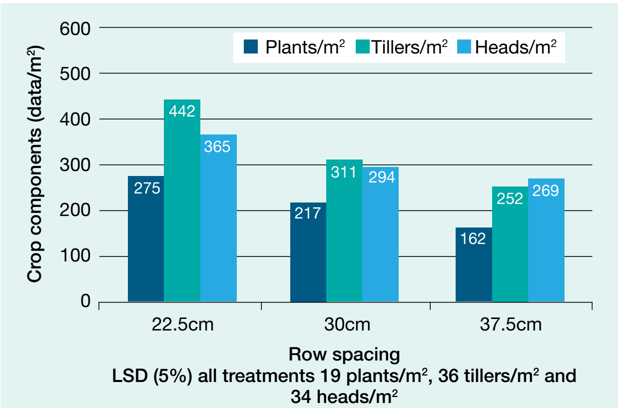


FIGURE 4 Influence of row spacing on crop structure*
*Mean of both openers

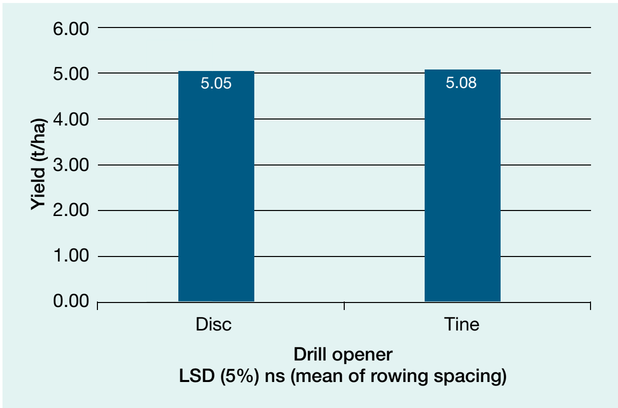


FIGURE 6 Influence of drill openers on yield*
*Mean of three row spacings

In last year's trial the yield reduction as row spacing moved from 22.5cm to 37.5cm was 16% (0.49t/ha), this year the figure was 12% (0.64t/ha). The principal difference between the 2010 and 2009 results was that with the higher yields experienced during 2010, 30cm was significantly inferior to 22.5cm while during 2009 there was no significant disadvantage moving from 22.5cm to 30cm (see Figure 5).

Note: 2009 data was taken from a replicate trial at the same paddock location, but from a different rotation position (wheat on wheat).

There was no significant difference ($p = 0.72$) in the influence of drill opener in the trial, with the tine yielding 5.08t/ha and disc yielding 5.05t/ha when averaged across the three row spacings (see Figure 6).

However, there was a significant interaction between row spacing and drill opener ($p = 0.03$), with an indication of significantly better performance from the tine opener at the 30cm row spacing. This correlates to significantly better establishment at the start of the season (see Figure 7).

The combination producing the highest yield in the trial (5.48t/ha) was achieved with the narrow row spacing and disc, though this was only 0.08t/ha higher yielding than the tine equivalent.

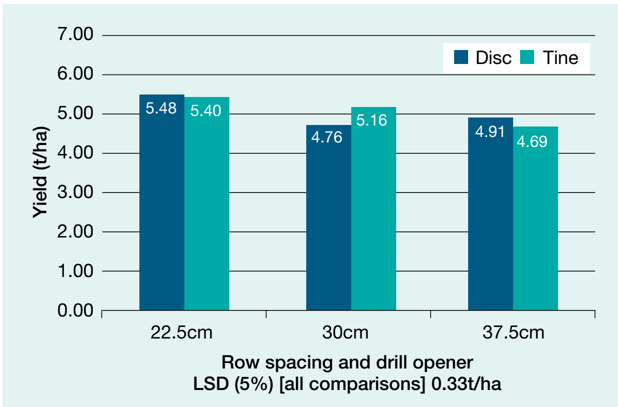


FIGURE 7 Influence of row spacing and drill opener on yield

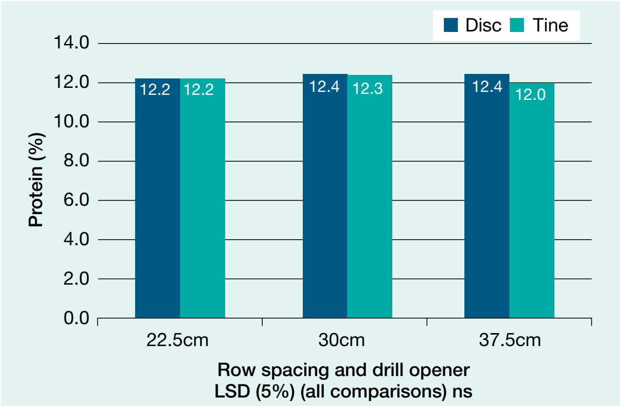


FIGURE 8 Influence of row spacing and drill opener on protein

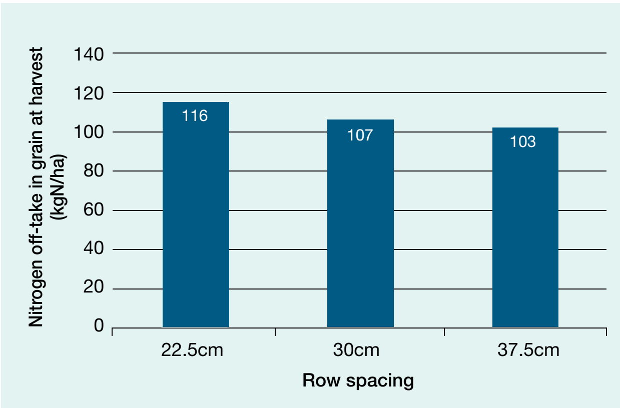


FIGURE 9 Influence of row spacing on nitrogen off-take

ii) Protein (%) and nitrogen off-take in the grain

There were no significant differences in protein associated with either row spacing or drill opener, despite significant differences in yield due to row spacing (see Figure 8).

As a consequence there was a greater nitrogen off-take in the grain at the narrower row spacing (116kg/ha of nitrogen at the narrow spacing and 103kg/ha at the wider spacing) (see Figure 9).

At present it is unclear whether this was the result of less nitrogen off-take overall with the wider row spacing or a different partitioning of nitrogen within the plant.

SPONSORS

This trial was carried out as part of the Riverine Plains Inc GRDC-funded project *Improved WUE in no-till cropping and stubble retention systems in spatially and temporally variable conditions in the Riverine Plains* (RPI00007).

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

CONTACT

Nick Poole
Foundation for Arable Research,
New Zealand
E: poolen@far.org.nz

Riverine Plains 2010 crop reflectance and nitrogen requirement trials

Brett Whelan [1], Adam Inchbold [2] and Mark Harmer [2]

[1] Australian Centre for Precision Agriculture (ACPA), University of Sydney

[2] Riverine Plains Inc

Key points

- Results from 2010 confirm previous investigations showing that paddock yield potential and underlying nitrogen (N) status vary considerably.
- This variation warrants variable rate nitrogen applications.
- Normalised Difference Vegetation Index (NDVI) maps made with CropCircle® sensors had a high correlation with tiller numbers, dry matter (DM) total nitrogen and final yield.
- By combining an NDVI map with ground truthing measurements (canopy nitrogen content and deep soil nitrogen) it is possible to predict the amount of nitrogen available to the crop to produce grain across paddocks.
- Knowing the amount of nitrogen in the crop, along with the requirements for target yields, means variable rate nitrogen applications can be refined.
- Crop nitrogen use efficiency declines as more nitrogen becomes available.
- Too much applied nitrogen can reduce yields.

Introduction

During 2010, trials were carried out on a number of paddocks near Dookie and Yarrawonga to explore the relationship between in-season crop reflectance, crop biomass and crop nitrogen content. In-season crop reflectance was measured using CropCircle sensors, which use NDVI (Normalised Difference Vegetation Index).

The ultimate goal is to assess the suitability of the data to assist in making decisions on crop nitrogen requirements as the season unfolds. In this report, one of the paddocks at Dookie is used as an example.

Results

Nitrogen prescription based on historical information and deep soil nitrogen tests

Following promising results during 2009, the trial was expanded to include an extra two paddocks and a variable rate nitrogen program. The paddocks were originally divided into four potential management classes based on soil electrical conductivity (EC_a), elevation and historical yield (see Figure 1a).

Class 1 only covered 9% of the area and included the tops of sandy ridges and areas with trees. From an input management perspective it was deemed that combining Class 1 with the similar and much larger surrounding Class 4 would simplify operations, while maintaining a large enough separation between the final three classes, as shown in red in Figure 1b.

Class 2 covered the area expected to be the highest yielding. Class 3 covered the lower-lying areas of the paddock, which were expected to be medium yielding.

Soil sampling for available nitrogen across the classes provided average class results (see Table 1). The higher-yielding Class 2 had more available nitrogen than the lower-yielding Class 1.

Yield targets were set at 4.5t/ha for Class 1 and 5.0t/ha for Classes 2 and 3. Crop nitrogen uptake required for these target yields (and 12% protein content) can be calculated as:

$$4500_{kg/ha} \times 0.12 \times 0.175 = 95_{kgN/ha}$$

$$5000_{kg/ha} \times 0.12 \times 0.175 = 105_{kgN/ha}$$

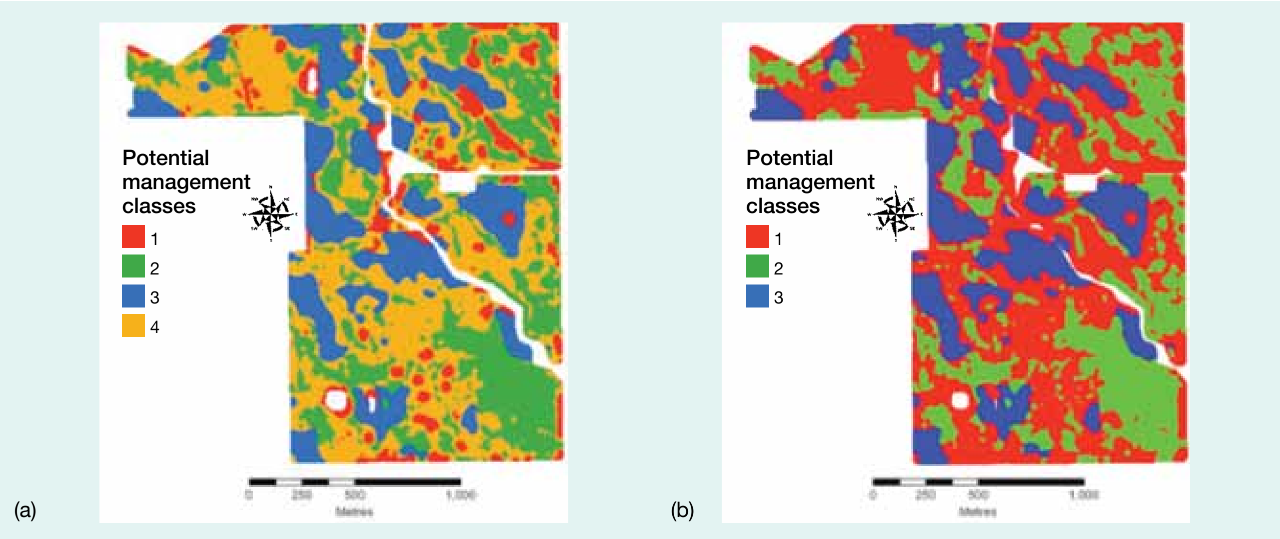


FIGURE 1 Four management classes (a) and the condensed three management classes (b)

TABLE 1 Class attributes and pre-sowing available nitrogen data for the three-class map (see Figure 1b)

Class	Soil EC_a	Yield	Elevation	Available nitrogen (kg N/ha)	Yield goal (t/ha)	Required crop nitrogen uptake (kg N/ha)	Available nitrogen shortfall (kg N/ha)
1	Low	Low	High	115	4.5	95	75
2	Medium	High	High	152	5.0	105	58
3	High	Medium	Low	144	5.0	105	66

Assuming a 50% nitrogen uptake efficiency, the shortfall in the soil at the time of sampling was calculated and is shown in Table 1. These figures were used to calculate an initial nitrogen prescription where more nitrogen was to be applied in the low-nitrogen Class 1, with the rates reducing for Class 2 and Class 3.

A prescription map was built from Figure 1b whereby the management zone boundaries were simplified and small unmanageable patches were absorbed into the majority class for a zone. Small strip rate trials were also included (see Figure 2a). The 'as applied' map from 8 July 2010 is shown in Figure 2b.

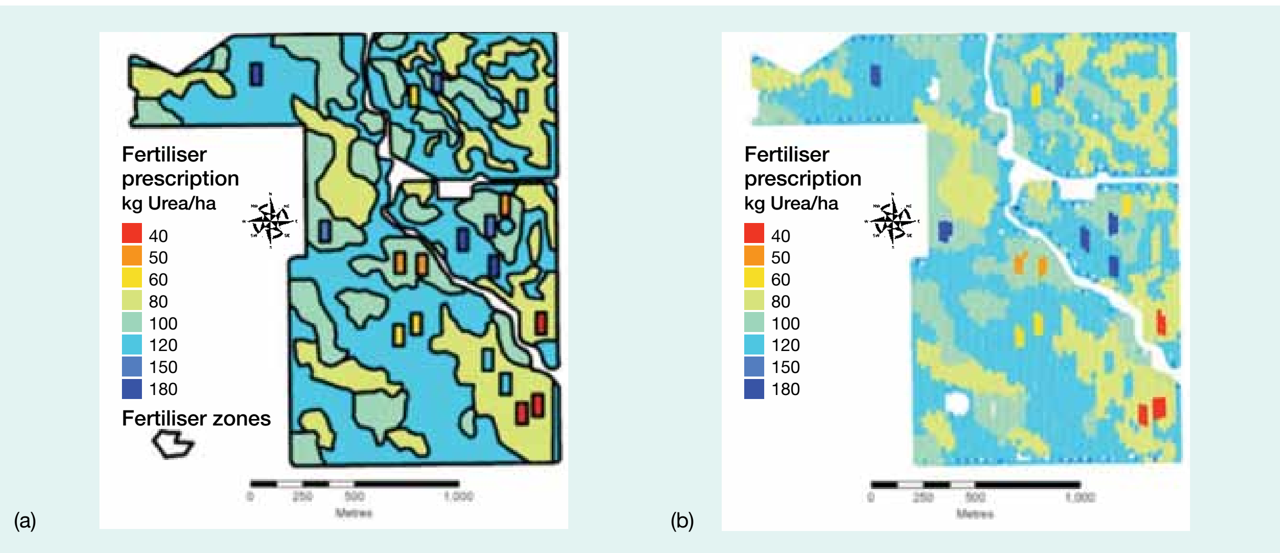


FIGURE 2 The initial nitrogen prescription map (a) and the 'as applied' variable-rate application map from 8 July 2010 (b)

The variable rate application of urea for padddock B1, took place on 8 July 2010, and is shown in more detail in Figure 3.

Reflectance measurement

Four CropCircle reflectance sensors were spread equally across a 25m boom and driven on a 25m swath survey within the paddock on 7 August 2010 (see Figure 4). The correlation between the reflectance during 2010 and 2009 was high (r=0.8), which suggests the data is strongly influenced by the interaction of local factors.

Crop samples were to be taken from the same sites as 2009 to measure crop nitrogen percentage, dry matter (DM t/ha) and shoots (m^2). Total nitrogen in the crop (kg/ha) can be calculated by:

$$TotalN_{(kg/ha)} = \frac{N\%}{100} \times (DM_{(t/ha)} \times 1000)$$

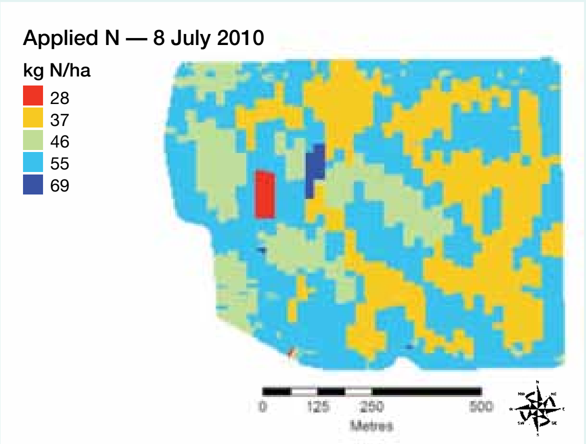


FIGURE 3 First nitrogen application based on three different application rates and including small strip trials

The season became quite wet following the reflectance survey, and access for sampling became impossible. Sampling was delayed, but the high correlation between the NDVI maps from 2009 and 2010, meant the calibration made from the 2009 sampling data could be applied to the 2010 reflectance data (see Figure 5).

This map predicted that some areas in the paddock had already taken up the required nitrogen to reach the 5.0t/ha yield target, but in Class 1 nitrogen levels remained low. The full soil moisture profile, the expectation for a productive season and the information shown in Figure 5 all supported the undertaking of a second variable rate urea application on 23 August 2010. The application map is shown in Figure 6a.

Continuing wet weather delayed crop sampling but encouraged a blanket application of an additional 46kg/ha of nitrogen to maximise yield and encourage higher grain protein content. The map of total nitrogen applied to the paddock is shown in Figure 6b.

Crop sampling

Crop sampling finally took place on 20 October, 2010 with the crop at mid milk stage (GS75).

Table 2 shows the relationships between the measured crop attributes and the NDVI. These relationships were generally stronger than during 2009. NDVI has a strong positive relationship with shoots/m^2 (r=0.74) and DM (r=0.91), however it demonstrates a poorer relationship with nitrogen percentage (N%) (r=0.22). A strong positive relationship with total nitrogen (r=0.85) can be seen due to the incorporation of the DM figure in the calculation.

Given the purpose of the sensors is to help manage nitrogen application, the prediction of total crop nitrogen from the reflectance data is a main goal. The prediction

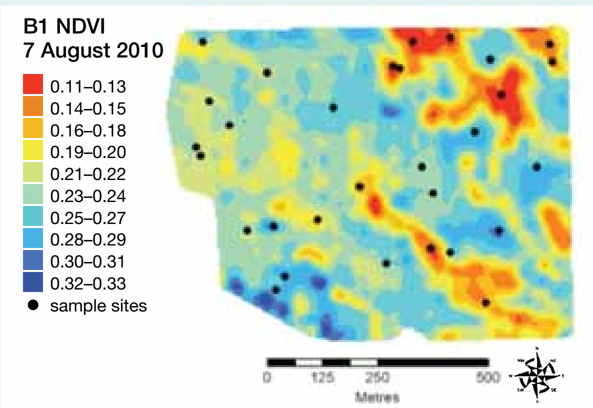


FIGURE 4 Crop reflectance data (NDVI) for the wheat crop on 7 August 2010 plus crop sampling sites

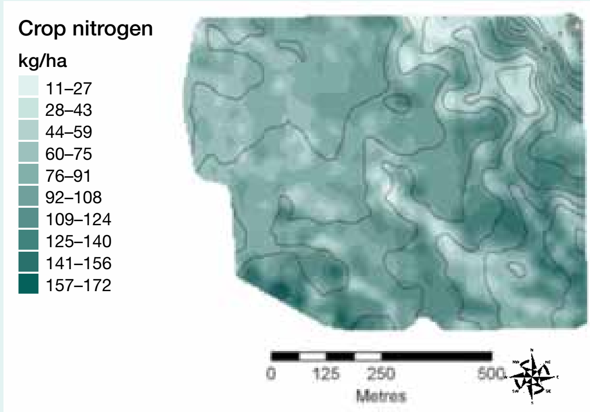


FIGURE 5 Total nitrogen uptake in the crop predicted from 2010 NDVI and the 2009 calibration

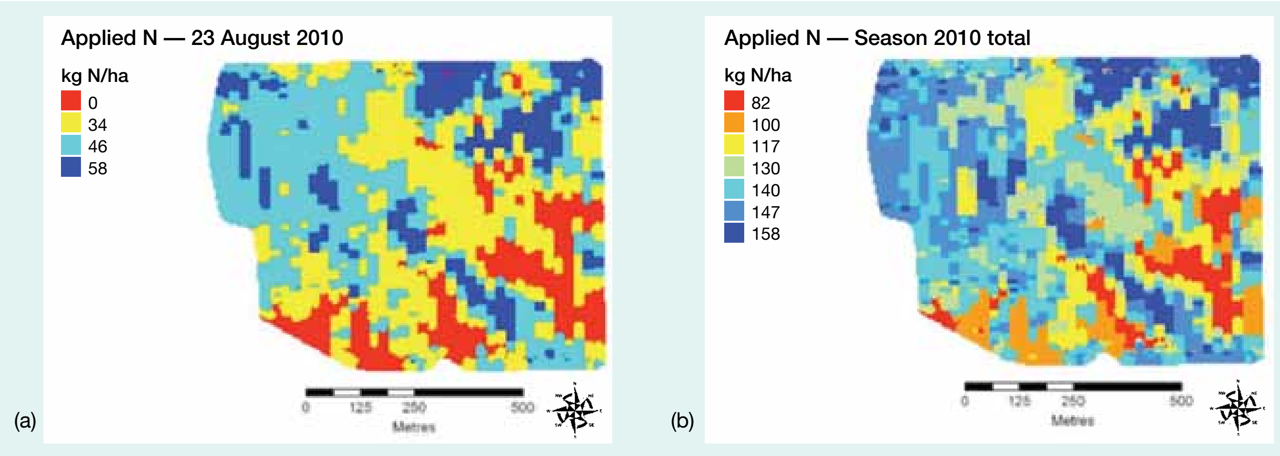


FIGURE 6 The second nitrogen application based on the 2010 reflectance data and the 2009 total nitrogen calibration (a) the total amount of nitrogen applied to the paddock (b)

TABLE 2 Relationships between the measured crop attributes at the sampling sites

	NDVI	Nitrogen (%)	DM	Shoots (m^2)	Total N (kg/ha)	Soil EC_a	Elevation	Yield
NDVI	1.00	0.22	0.91	0.74	0.85	-0.02	-0.30	0.82
Nitrogen (%)	0.22	1.00	0.24	0.41	0.58	-0.12	-0.13	0.12
DM	0.91	0.24	1.00	0.83	0.92	-0.17	-0.01	0.86
Shoots (m^2)	0.74	0.41	0.83	1.00	0.86	0.33	-0.34	0.66
Total N (kg/ha)	0.85	0.58	0.92	0.86	1.00	-0.21	-0.02	0.74
Soil EC_a	0.16	-0.13	0.05	-0.26	-0.02	1.00	-0.56	0.14
Elevation	-0.39	-0.05	-0.34	-0.16	-0.29	-0.56	1.00	-0.49
Yield	0.82	0.12	0.86	0.66	0.74	0.14	-0.49	1.00

Correlation coefficient interpretation: 1 = perfect positive correlation - as the value of one attribute rises, so does the other by the same relative amount; -1 = perfect negative correlation – as the value of one attribute rises, the other falls by the same relative amount. For N = 30 samples: values greater than +/- 0.36 significant at p = 0.05. Values greater than +/- 0.46 significant at p = 0.01.

can be improved by combining some basic information that should be available to most precision agriculture (PA) growers (elevation and soil ECa) with the NDVI data. In this paddock, the inclusion of elevation significantly improved the predictive ability from an R2 value of 0.71 to 0.74 (see Figure 7a). This calibration was applied to the NDVI map to produce the map of total crop nitrogen (see Figure 7b).

While this map was made using NDVI and crop sample data taken eight weeks apart, the calibration is quite strong. As was shown during 2009, when two NDVI surveys were taken three weeks apart, the pattern has been stable in this paddock.

The data shows the NDVI taken just prior to first node stage (GS30) can be used to predict the pattern and amount of nitrogen uptake at GS75. This is a significant finding for the practical use of these tools in nitrogen management.

Figure 7b shows the crop across the entire paddock is predicted to have taken up enough nitrogen to achieve yields above the initial targets.

Efficiency of converting crop nitrogen to final grain yield

Figure 8a shows the conversion rate of crop nitrogen into crop yield decreases as the total amount of nitrogen in the crop increases. So the more nitrogen taken up by the crop, the less efficient the plant is at using nitrogen to photosynthesise and produce grain. Figure 8b shows that while this is occurring, the crop yield of the plant still rises with increased nitrogen up to about 250kg/ha. Past this level there appears to be an absolute waste of nitrogen.

During 2009, where there was a lower amount of moisture available for crop growth, the total nitrogen in the crop at sampling was less than during the 2010 season. This was also the case for yields. The combination of the data from the two seasons is shown in Figure 9. The data was gathered from an eight-week window of observation from GS30 to GS75.

These graphs show the data corresponds well and provides a useful guide to the production output and efficiency limits that can be expected with regard to nitrogen and wheat yields across a reasonably broad nitrogen and yield range.

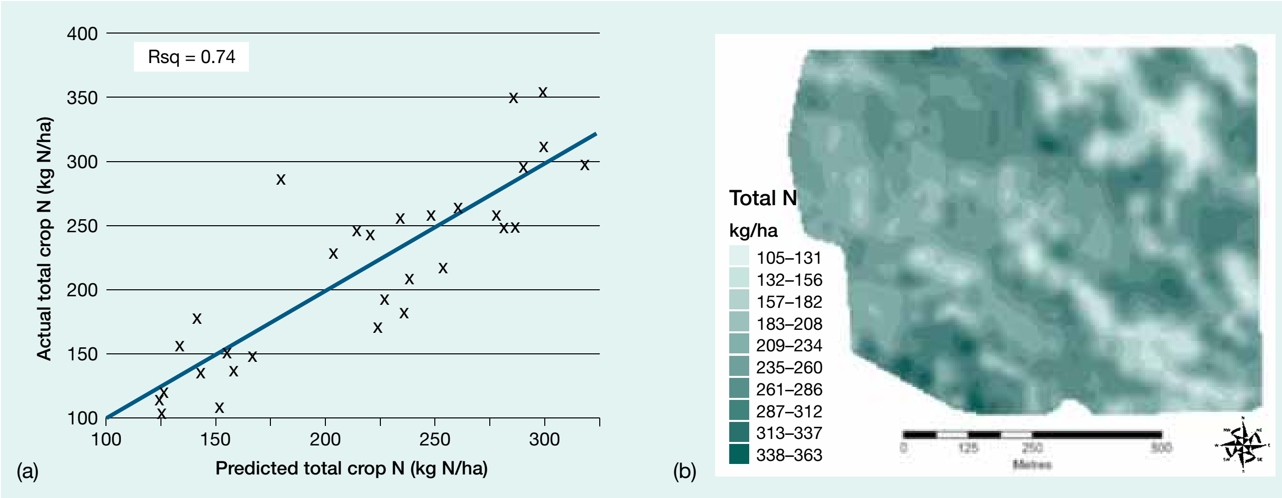


FIGURE 7 Calibration of crop nitrogen predicted by the NDVI and the actual crop nitrogen (a) and the result of applying this calibration to the whole paddock NDVI data (b)

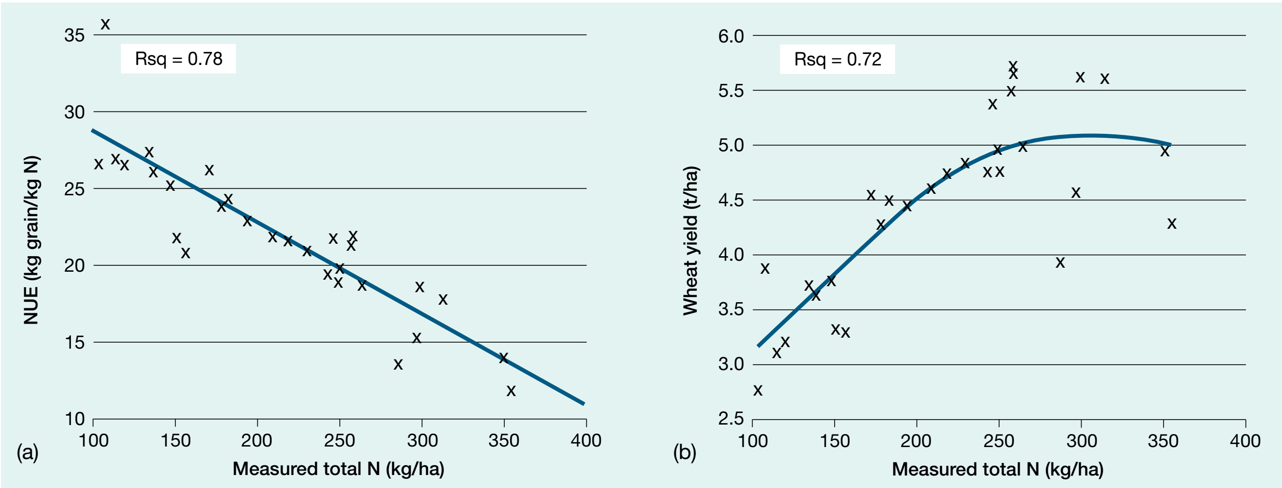


FIGURE 8 The efficiency with which crop nitrogen is converted to grain (a) and the absolute yield relative to crop nitrogen (b)

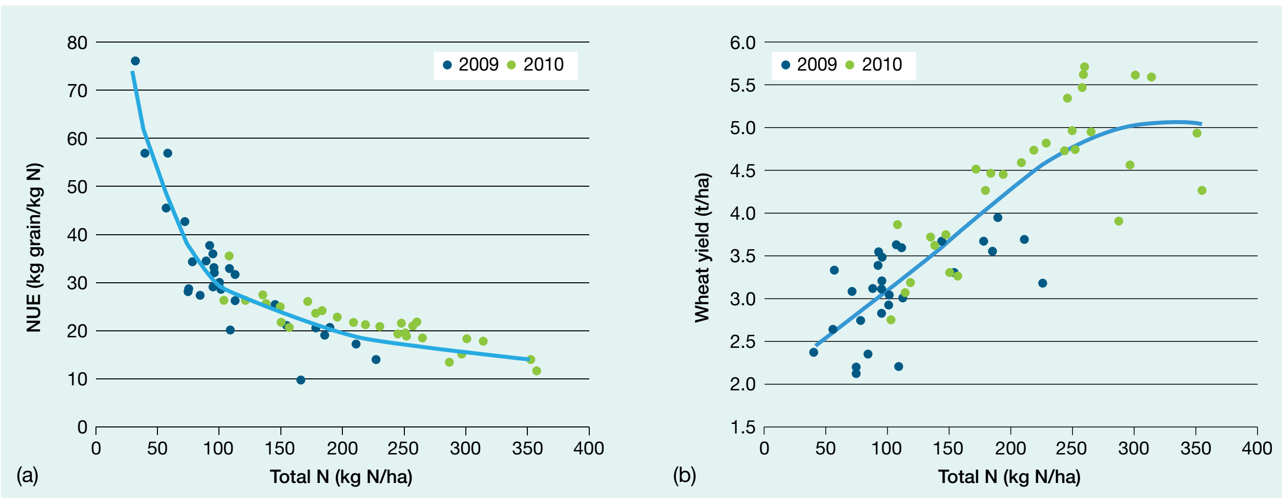


FIGURE 9 Combination of the 2009 and 2010 data for efficiency with which crop nitrogen is converted to grain (a) and the absolute yield relative to crop nitrogen (b)

Yield response to total applied nitrogen

The 2010 wheat yield map is shown in Figure 10. As shown in Table 2, the correlation between the NDVI and the final yield (r=0.82) is significant from a statistical and agronomic management point of view. While there was some minor frost damage, yields during 2010 were not water limited and, excepting the sand ridges, 85% of the crop was able to reach or exceed the yield targets. With such conditions, it is good to see that the data taken from the reflectance sensors during the season could be relied on to provide information relevant to final crop production.

The average response of the crop to the different rates of nitrogen fertiliser is shown in Figure 11.

The original four classes have been used for the analysis to explore whether there are significant differences between the two Classes (1 and 4) that were combined for fertiliser management.

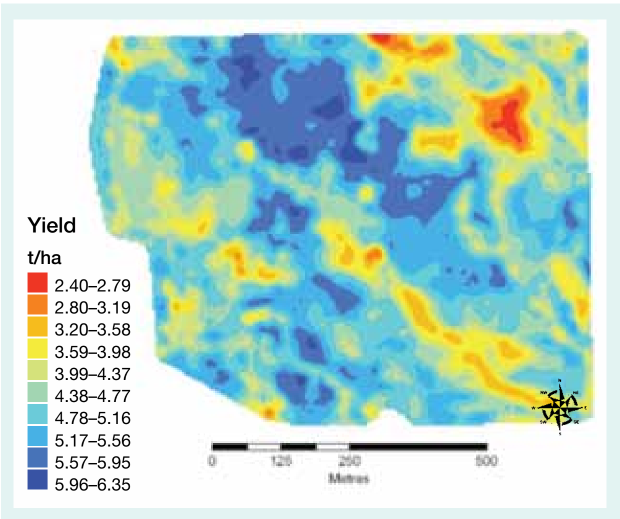


FIGURE 10 Wheat yield map for the 2010 season

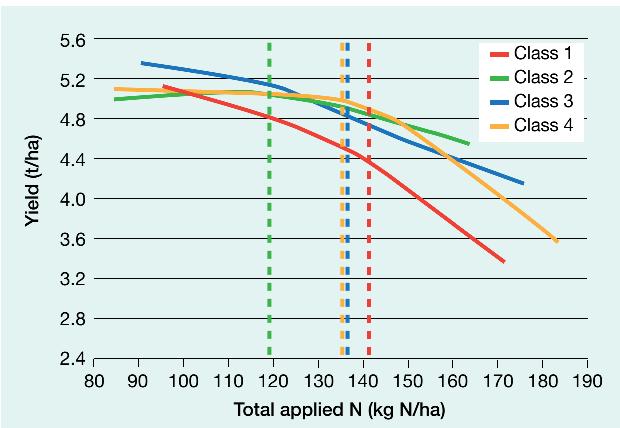


FIGURE 11 Wheat yield response to applied nitrogen fertiliser for each management class. The average applied for each class is shown by the correspondingly-coloured dashed line

As can be seen from Figure 11, the responses for Class 1 and 4 are quite different. While Class 1 may be small, it appears that chasing greater yields with more nitrogen fertiliser may not be warranted in this case. Classes 2 and 4 appear to be more similar in response and may be a better choice for combination in any future management.

All the classes appear to have received more nitrogen than was considered optimum for their final yield, however, the frost during late September may have held back yield, which would have contributed to this result.

Three traditional blanket applications in this season would have seen 138kg/ha of nitrogen applied to the paddock. The average application for Classes 1, 3 and 4 were close to this rate, but in Class 2, 20kg/ha has been saved with no yield penalty.

Results from the other two paddocks will be combined to provide greater analysis of the response from the Classes and help direct any changes to management.

Summary

The current sensing systems can assess the vegetative production (DM and shoots/m^2) and 'health' of the crop, which can help diagnose establishment and growth issues. Ground truthing can help calculate the amount of nitrogen-uptake.

The relative amounts of nitrogen in the crop, predicted by the sensors, follows the pattern expected from the different amounts of soil nitrogen before fertiliser application. This certainly lends itself to directing variable rate fertiliser applications where in-season differences are detected.

In non-water-limited seasons it appears the prediction of later-season nitrogen uptake patterns from surveys performed earlier during the season is robust, which has encouraging implications for successful in-season nitrogen management.

SPONSORS

This trial was carried out as part of the Riverine Plains Inc GRDC-funded project *Improved WUE in no-till cropping and stubble retention systems in spatially and temporally variable conditions in the Riverine Plains (RPI00007)*. Crop sensing hardware was donated by gps-Ag.

CONTACT

Riverine Plains Inc
T: (03) 5744 1713
E: info@riverineplains.com.au

Impact of summer cropping on subsequent wheat crops

Charlotte Aves, Kithsiri Dassanayake and David Cook
The University of Melbourne and Riverine Plains Inc

Key points

- Adequate crop nutrition following summer crops is essential for optimised winter grain yield.
- Soil moisture was not limiting this season; therefore wheat yield responses were driven by crop nutrition.

Location: Pine Lodge, East Shepparton, VIC

Rainfall:
Annual: 863mm
GSR: 583mm

Soil:
Type: Sandy clay loam — clay loam
pH (H_2O): 4.9–6.8 (0–20cm)

Paddock history:
2009–10 — summer cropping trial
2008 — wheat
2007 — canola

Plot size: 27m^2

Replicates: 9

Aims

To investigate the impacts of summer cropping on subsequent winter crop (wheat) yield.

To determine nitrogen (N) response of wheat following summer crops.

Method

Five summer crops (millet, lablab, mung beans, sunflower and safflower) were planted in 1.2ha plots during the 2009–10 summer and compared against a chemical fallow for soil moisture. These summer crop blocks were replicated three times.

During 2010 a wheat crop was sown across the entire trial area (see Table 1).

Six fertiliser treatments were applied parallel to the previous year's summer cropping treatments at two different growth stages — first node development (GS31) and flag leaf emergence (GS39–49) (see Table 2 and Figure 1).

Emergence counts, tiller counts, ear numbers, biomass measurements were carried out at first node development (GS31) and flowering (GS65).

Soil tests, including deep nitrogen testing (DSN) were carried out in the different summer crop blocks before sowing and will be carried out after harvest.

Soil moisture sensors recorded soil moisture, temperature and electrical conductivity (EC).

TABLE 1 Sowing details of 2010 wheat crop at Pine Lodge

Sowing date	19 May 2010
Variety	Lincoln
Sowing rate	52kg/ha
Fertiliser at sowing	80kg/ha MESZ

TABLE 2 Fertiliser treatments applied to wheat crop at Pine Lodge

Nitrogen treatment	Fertiliser rate applied at GS31 (kg/ha)	Fertiliser rate applied at GS39–49 (kg/ha)
1	0	0
2	40	0
3	80	0
4	120	0
5	40	40
6	60	60



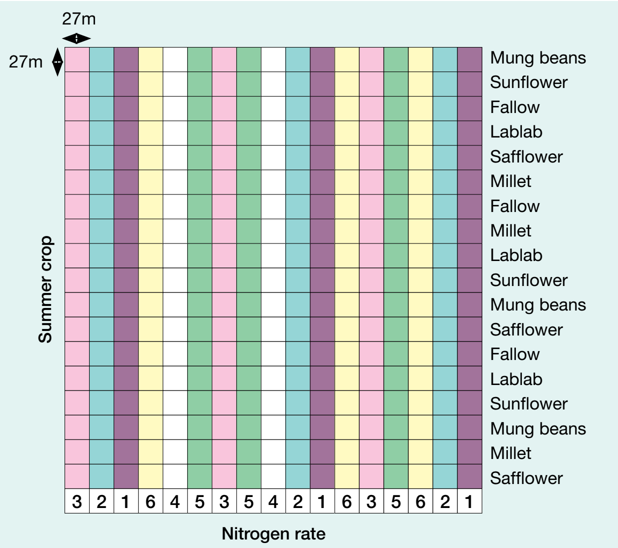


FIGURE 1 Trial layout

Results to date

2009–10 summer crop

Summer crops generally performed well, however millet was the most successful crop producing a substantial grain yield and biomass (see Table 3). This indicates its potential as a summer grain and fodder crop.

Wheat crop performance before first nitrogen application

Wheat seedling emergence in plots previously under safflower, mung beans and fallow was higher than the other plots. The target population was 150 plants/m^2, so lablab and sunflowers were the only two plots significantly below target population.

Growth assessment data indicated that millet impacted negatively on wheat growth. For example, tiller counts taken 82 days after sowing (DAS) were significantly lower in plots previously under millet (see Table 4).

Given the growing season's cool and wet conditions, this negative effect could not be attributed to reduced soil moisture storage after millet. Subsequent observations indicated soil nitrogen levels in plots previously under millet and lablab were markedly lower than the other plots (see Figure 2).

The millet block showed visible signs of nitrogen deficiency, indicating that millet might have depleted more soil nitrogen than other summer crops. This highlights the importance of understanding the impacts of summer cropping on nitrogen availability in addition to the impacts of soil, water and soil-water interactions.

Wheat yield

Unfortunately the wheat crop could not be harvested due to rainfall-induced lodging and significant sprouting. The effect of nitrogen levels on grain yield was not evaluated as final yield results were not available.

However, the number of ears per square metre, recorded on 8 November 2010 at milk development (GS75), was used to estimate potential yield. The results indicate that both nitrogen and summer crop type significantly affected potential yields (see Figure 3).

TABLE 3 Harvested grain and dry matter yield for summer crops at Pine Lodge 2009–10

Summer crop	Grain yield (t/ha)	Dry matter yield (t/ha)	Notes
Lablab	n/a	6.34	Quadrat samples cut on 31 March 2010
Mung beans	0.51		Harvested on 17 April 2010
Millet	2.35	9.66	Grain harvested 17 April 2010; dry matter cut 31 March 2010
Safflower	0.51		Harvested 2 March 2010
Sunflower	0.17		Harvested 20 April 2010 — significant seed loss due to late-season bird damage and harvest losses as sunflower trays not used on header

TABLE 4 Rates of seedling emergence (61 DAS) and tillering (82 DAS) of wheat under various cropping treatments at Pine Lodge 2010

Previous summer crop	Emergence (plants/m^2)	Tillers/m^2	Difference in tiller numbers compared with fallow (%)
Fallow	151	431	n/a
Lablab	137	441	2
French millet	145	384	-11
Mung beans	150	511	19
Safflower	158	484	12
Sunflower	131	511	19

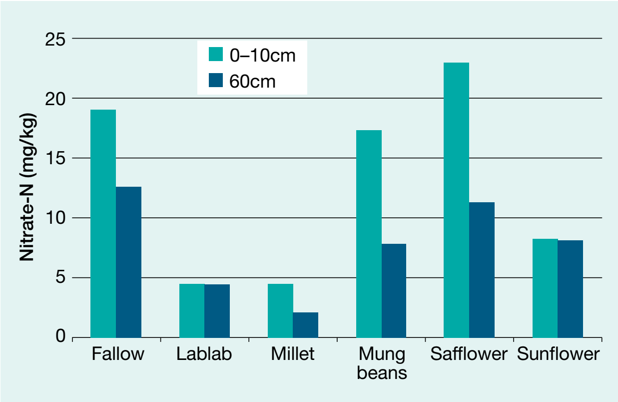


FIGURE 2 Soil nitrogen levels before wheat crop was sown at Pine Lodge 2010

Observations and comments

Summer cropping has the potential to spread risk by increasing the number of crops within the rotation. The reduction in wheat yield following a millet crop, and the differential response of wheat to different nitrogen applications, shows the importance of adequate winter crop nutrition following summer crop production.

Unfortunately record rainfall during 2009–11 meant this project was unable to determine whether summer cropping impedes wheat growth as a result of depleting soil moisture reserves.

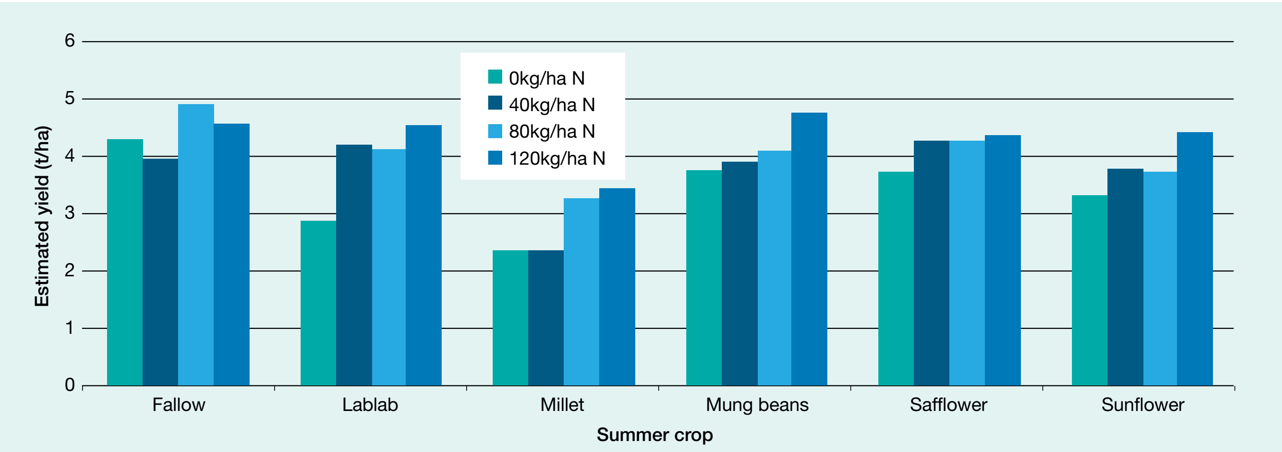


FIGURE 3 Estimated wheat yield as affected by previous summer crop and nitrogen levels at Pine Lodge 2010

This research was undertaken by Riverine Plains Inc and the University of Melbourne in partnership with the Farms, Rivers and Markets (FRM) project. FRM is funded by the National Water Commission, the Victorian Water Trust, the University of Melbourne, and the Dookie Farms 2000 Trust (Tallis Trust).

CONTACT

Charlotte Aves

University of Melbourne

T: 0409 697 352

E: caves@unimelb.edu.au

Gason CGE stubble mulchers are simply a cut above the rest

If you're into serious continuous cereal cropping you'll know the benefits of stubble mulching and you'll know that a Gason CGE Cropper Topper is the right machine for your crop, your property and our Australian farming conditions.

Gason CGE Cropper Topper delivers a higher level of trashing efficiency. Dual mulching blades operating at high tip speeds provide the rapid trashing of incoming stubble, primary cutting blades are suction up lift and twisted and create the air movement so cuttings are discharged evenly without windrowing.

- Fast operating speeds of up to 15 KPH*
- Sturdy machine design and construction for dependable service
- Hydraulic actuated wing lift models with PTO shafts connected
- Gason CGE Cropper Toppers can also be used for green grass pasture topping and weed control.
- An above deck debris fan option

Models available are;

- 5.9m (20ft) cutting width, trailed flat deck model
- 7.14m (24ft) trailed winglift model
- 9.15m (30ft) trailed winglift model
- 10.67m (35ft) trailed winglift model
- 12.47m (41ft) trailed winglift model

Australian designed and manufactured for our country.

For full details and prices, see your nearest Gason CGE dealer, or contact

GASON CGE MOWERS&SLASHERS

Blake Street ARARAT VIC 3377
PHONE (03) 53 522 151

(*Subject to compatible tractor specifications and suitable ground conditions)

Wheat inputs experiment

John Sykes
John Sykes Rural Consulting

Key points

- Plant densities above about 70 plant/m^2 (35kg/ha of seed) can produce similar yields to crops sown at normal rates (60–80kg/ha for 120–170 plant/m^2) when phosphorus (P) is applied at sowing and nitrogen (N) application is restricted to low levels until first node (GS31).
- In high-rainfall years, 70 plants/m^2 will produce lower yields than crops with higher plant numbers, unless some nitrogen is applied at the five-leaf stage (GS15). If nitrogen is applied at GS15, similar yields can be obtained.
- There may be opportunities to use phosphorus in crop to maximise yields. More work needs to be carried out to confirm this.
- Lower than optimal tiller numbers can still produce acceptable yields and water use efficiencies in (WUE) wet years.

Location: Balldale, NSW

Rainfall:
Annual: 855mm (av 504mm)
GSR: 426mm (av 319mm)
Sowing moisture: Field capacity

Soil:
Type: Red chromosol
pH ($CaCl_2$): 5.3
P (Colwell): 43mg/kg
Deep soil nitrogen: 53kg/ha

Sowing information:
Sowing date: 22 May 2010
Variety: Ventura (untreated)
Row spacing: 18cm

Paddock history:
2009 — wheat
2008 — canola (hay)

Plot size: 1.5m x 16m

Replicates: 3

Aim

To assess if the previous year's results from this experiment could be replicated in a year with average to above average growing season rainfall (GSR).

Method

A replicated experiment was established to test the effect of varying seed and phosphorus and nitrogen fertiliser inputs on tiller count and yield of wheat.

2010 results

See Table 1 for results.

TABLE 1 2010 results for the wheat inputs experiment

Treatment summary	Plants (plants/ m^2)	Tillers (tillers/ m^2 at GS30)	Yield (t/ha)	Gross margin ($/ha)
S35/P0/N0+0	67	221	2.8	428
S35/P20/N0+0	68	322	3.8	508
S35/P20/N0+20	72	290	4.0	503
S35/P20/N0+40	71	283	4.7	598
S35/P20/N0+80	75	310	5.5	684
S35/P20/N20+20	72	367	5.3	707
S35/P20/N20+60	74	389	6.4	853
S35/P15/N0+40	74	281	4.8	634
S70/P0/N0+0	124	307	3.2	457
S70/P20/N0+0	124	468	3.9	500
S70/P20/N0+20	127	511	4.4	567
S70/P20/N0+40	120	499	5.5	746
S70/P20/N0+80	119	509	6.5	855
S70/P15/N0+40	121	290	5.0	669
S70/P5/N0+40	129	377	4.6	624
S70/P5+15[1]/N20+60	121	614	6.4	836
S70/P5+10+5[1]/N0+40	120	444	4.9	626
S70/P5+0+15[1]/N0+40	135	355	4.4	538
S70/P0+10+10[1]/N0+40	127	293	3.8	426
S35/P5+15[1]/N20+60	73	571	6.4	845
LSD (0.05)	33	64	0.4	74
Standard deviation	18	61	0.7	
Mean	101	385	4.8	
CV	17.8%	15.7%	14.5%	

Sowing rate (kg/ha) / phosphorus rate (kg/ha) / nitrogen rate (kg/ha). Phosphorus (P) fertiliser as triple super applied at sowing unless otherwise stated. Nitrogen (N) applied as urea in a split application at GS15 and GS31. First number in the nitrogen column is the amount of nitrogen (kg/ha) applied at GS15 and the number after the plus (+) is nitrogen (kg/ha) applied at GS31.

[1] In these treatments phosphorus applied at sowing, GS15 and GS31 at the rate (kg/ha) indicated. First number is the amount applied at sowing + phosphorus applied at GS15 + phosphorus applied at GS31.



Observations and comments

Results from 2010

- Plant densities of about 70 plants/m^2 (from 35kg/ha of seed) resulted in significantly lower yields than plant densities of about 125 plants/m^2 (from 70kg/ha of seed), unless nitrogen was applied at about growth stage GS15.
- Providing 20kg/ha of nitrogen was applied at GS15, 70 plant/m^2 produced yields that were not significantly different to those produced from the higher (125 plants/m^2) plant density.
- Applying nitrogen at GS15 (five-leaf stage) significantly raises tiller numbers.
- So long as 5kg/ha of phosphorus is applied at sowing, more phosphorus can be added at GS15 and produce yields that are not significantly different to those produced from the same amount of phosphorus applied at sowing.
- Applying this additional phosphorus at GS31 produced yields that were significantly lower than those produced by applying it all at sowing.

Results from the three years' work

- Yields of wheat can be maximised from plant numbers of about 70 plants/m^2. From these experiments, these plant densities could be produced from about 35kg/ha of seed sown using a tined machine with 18cm spacings.
- Plant densities of less than about 70 plants/m^2 significantly reduces yields in a year with close to average GSR.
- When compared with the plant numbers produced from 70kg/ha of seed (125–150 plants/m^2), 35kg/ha of seed (70 plants/m^2) produced:
  - Significantly higher yields in low GSR years.
  - Similar yields in average GSR years.
  - Significantly lower yields in wetter than average GSR years, unless nitrogen is applied at about the GS15 stage.
- Applying nitrogen at GS15 significantly raises tiller numbers and thus yield.
- Optimum phosphorus rates vary from 5–15kg/ha depending on the original phosphorus soil test levels and possibly the yield potential.
- Optimum tiller numbers are 250–400 tillers/m^2 at GS31 depending on the yield potential. This is lower than the usually accepted target of 500 tillers/m^2.
- There may be opportunities to split phosphorus fertiliser applications provided a minimum of 5kg/ha is applied at sowing. Further work needs to be carried out to confirm this.
- Additional amounts of in-crop phosphorus can be applied until about GS15 to produce yields that are not significantly different to the same amount applied at sowing.

SPONSORS

Grains Research and Development Corporation (GRDC) through a Southern Agribusiness Extension Grant, Mr C Cay, Mrs S Cay, Mr O Smith.

CONTACT

John Sykes
John Sykes Rural Consulting
T: (02) 6023 1666
E: johnsykes3@bigpond.com

Tungamah summer forage trial

Dale Grey
DPI Victoria, Cobram

Key point

- Forage sorghum was the highest yielding forage in a record summer rainfall year.

Location: Tungamah, Victoria

Rainfall:
November–February average: 130mm
November–February 2010–11: 441mm

Soil:
Type: brown loam over medium clay

Sowing information:
Sowing date: 11 November 2010
Fertiliser: 60kg/ha DAP
Harvest date: 8 March 2011
Row spacing: 17.5cm

Paddock history:
2010 — pasture
2009 — pasture
2008 — pasture

Plot size: 15m x 1.4m

Replicates: 3

Aim

To test the growth of a number of summer and winter growing forage species during summer as part of the *Grain and Graze 2* adaptive forage program.

Method

Rainfall during summer has been high during recent years and this is predicted to become more prevalent in the future.

This experiment looks at how growers can make more use of seasonal rainfall for crop production rather than growing weeds during summer.

The paddock was disc cultivated to remove windmill grass and weeds were knocked down with glyphosate before sowing with a cone seeder.

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
- Pacer grain sorghum sown at 10kg/ha
- Maize sown at 25kg/ha
- Hindmarsh spring barley sown at two sowing rates — 50kg/ha and 100kg/ha
- Urambie winter barley sown at 50 kg/ha
- Wedgetail winter wheat sown at two sowing rates — 50kg/ha and 100 kg/ha
- Bouncer hybrid brassica (turnip x chinese cabbage) sown at 5kg/ha
- Taurus winter-habit canola sown at 2kg/ha
- Djakal soybean sown at 50kg/ha
- Emerald mungbeans sown at 30kg/ha

Results and conclusions

The site received 28mm two days after sowing on the 11 November 2010. None of the winter cereals or the brassicas emerged and the maize had poor emergence. The summer grasses emerged well at 50 plants/m^2, the soybeans were excellent at 34 plants/m^2 with the mungbeans poor at 17 plants/m^2.

The Boosey Creek flooded the broadleaf species end of the site during early December for a period of three days, affecting soy and mungbeans survival in some areas.

Before Christmas, locusts flew in and were observed eating many species. Shirohie, pearl millet and maize were the worst affected, being grazed to ground level by the locusts while forage sorghum was the least attacked.

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

Fodder crop	Dry matter yield (t/ha)
Shirohie millet	5.3
Pearl millet	7.1
French millet	7.8
Emerald mung beans	6.1
Mung beans grain	0.4
Sprint forage sorghum	30.1
Pacer sorghum	10.6
P	0.62
LSD	ns
CV%	54

Hares preferentially grazed the soybean plants during summer and mice started eating the grain out of the heads during mid-March, with the grain sorghum and pearl millet most affected. Locusts were again eating leaf during late March with Shirohie millet the worst affected.

Despite all these calamities, some species grew very well in what was the record wet summer for this area (see Table 1). The performance of forage sorghum was particularly impressive. The large site variability lead to a poor statistical outcome and the yields are indicative only.

Cooperators: Josh and Jenny Buerckner

SPONSORS

DPI Victoria and Grains Research and Development Corporation (GRDC) as part of the *Grain and Graze* 2 program.

CONTACT

Dale Grey
DPI Victoria
T: (03) 5871 0600
E: Dale.Grey@dpi.vic.gov.au

Evaluation of rhizobial inoculants in the Riverine Plains

David Pearce and Lori Phillips
DPI Victoria, Rutherglen

Key points

- Inoculating with root nodule bacteria (*Rhizobium*) at sowing increases plant production in soils where *Rhizobium* populations are low.
- The standard 'peat slurry on seed' inoculant delivery method provides consistent nodulation responses, resulting in increased grain yield and dry matter production.
- Co-inoculant formulations are as effective as standard inoculant formulations at promoting nodulation and increasing dry matter (DM) production and grain yield.

Aim

The aim of this study was to assess the impact of different inoculant delivery systems (granular and liquid) on effective nodule formation and to evaluate the influence of co-inoculant formulations on legume growth and yield.

Background

Legumes form mutually-beneficial associations with nitrogen-fixing *Rhizobium* bacteria (rhizobia).

Rhizobia enter plant roots soon after seed germination and are eventually enveloped in nodules, where the bacteria convert atmospheric nitrogen into a form available for plant use. Inoculation is often required to provide sufficient numbers of suitable rhizobia on or near the germinating legume seed, so effective nodules can form.

There is a range of different delivery systems and products growers can choose from to inoculate their legume crops.

Traditionally, the main inoculation delivery system has been peat slurry application, where the seed is coated with the appropriate rhizobia just before sowing. Although very effective, this method can be troublesome and time-consuming. Alternate methods could simplify the delivery of rhizobial inoculants. These methods include the placement of granular carriers and the injection of slurry mixes (peat, water, and rhizobia) directly into the sowing furrow. Manufacturers have also developed co-inoculant formulations, which combine rhizobia with other microorganisms. These co-inoculants could assist in nutrient uptake or general plant growth.

As the number of products on the market increases, so too does the need to evaluate their performance under different conditions to ensure growers can choose the best product for their paddock.

Following are the results of several trials undertaken with faba and lupin crops in north-east Victoria and southern New South Wales. The aim of these trials was to assess the impact of different inoculant delivery systems (granular and liquid) on effective nodule formation and to evaluate the influence of co-inoculant formulations on legume growth and yield.

Methods

Inoculant rates and application procedures were carried out according to manufacturer recommendations. Table 1 summarises the treatments used in the trials.

Peat slurry inoculation treatments were applied to the seed two hours before sowing and carried out by spraying the slurry mix into the sowing furrow.

Peat-based granular inoculants were sown at the same depth as the seed and fertiliser.

Legume crops were sown into moist soil using an eight-row cone seeder, with 18cm row spacing.

The cone seeder was sterilised with ethanol between the different treatments in order to minimise cross contamination.

Plots were sown in randomised complete blocks with six replicates, with a plot length of 15m.

Plots were continually monitored throughout the growing season and weeds, insects and fungal pathogens were controlled with the appropriate spray applications.



TABLE 1 Different rhizobial delivery methods and treatments evaluated

Treatment	Inoculant description	Delivery method	Application rate
Peat slurry	Rhizobia (Nodulaid [1])	Peat slurry applied to seed	250g peat to 100kg seed
Biostacked [1]	Rhizobia + *Bacillus subtilis*	Peat slurry applied to seed	250g peat with 2ml *B. subtilis* (Integral) to 100kg seed
TagTeam [2]	Rhizobia + *Penicillium bilaii*	Peat slurry applied to seed	250g peat to 100kg seed
Peat granules	Rhizobia (Nodulator [1])	Peat granules	Sown at same depth as seed at a rate of 6kg/ha
Peat inject	Rhizobia (Nodulaid [1])	Peat slurry injected into drill row	Based on 250g peat per 100kg seed; injected at a rate of 50L/ha
Nil	No rhizobia applied		

[1] Becker Underwood product
[2] Novozyme product

Results

These field trials highlighted the importance of inoculation in soils with low background populations of compatible *Rhizobium* (see Tables 2 and 3), with significant increases in grain yield and DM production occurring in all inoculated treatments compared with nil treatments.

However, where large populations of compatible *Rhizobium* were present at sowing there was little increase in nodulation responses with inoculation (see Table 3, lupin plots).

The standard peat slurry on seed delivery method was a consistent performer at our trial sites, which is a trend we have seen in other trials carried out in Victoria and southern NSW. This delivery method resulted in increased nodulation compared with the other methods, and increased DM production compared with the peat granule method.

The co-inoculant formulations were as effective as the single inoculant (applied as peat slurry on seed) in promoting nodulation and increasing DM production and grain yield.

Observations and comments

These trial results highlight the value of inoculation at sowing to maximise plant performance. In general, increased nodulation resulted in higher grain yields and DM production, particularly with faba bean crops.

Increased DM production equates to more nitrogen fixed within the cropping system as a whole. This leads to proportionally greater inputs of nitrogen-rich residues, with the potential for improved yields in subsequent crops.

TABLE 2 Nodulation, herbage and grain yield faba bean and lupin crops at the NSW site in response to different inoculant delivery methods and products

Treatment	Nodules per plant		Crop production (t/ha)	
Faba bean cv. Farah	Number	Weight (mg)	Dry matter	Grain yield
Nil	0.02	0.4	5.97	1.75
Peat slurry	14.1	174	11.61	3.69
Biostacked	16.2	175	10.04	3.47
TagTeam	16.5	237	10.50	3.58
Peat granules	5.0	126	8.98	3.50
Peat inject	2.4	50	8.40	2.70
LSD*	6.5	12	2.37	0.41
Lupin cv. Jindalee	**Number**	**Weight (mg)**	**Dry matter**	**Grain yield**
Nil	0.07	0.1	7.76	3.45
Peat slurry	23.73	101	9.18	3.69
Peat granules	5.48	43	7.35	3.67
Peat inject	10.9	80	8.08	3.92
LSD*	4.2	23	1.94	0.55

* LSD-Least significant differences indicate where statistically significant differences were observed

TABLE 3 Nodulation responses of faba bean and lupin crops at the Victoria site in response to different inoculant delivery methods and products*

Treatment	Nodules per plant	
Faba bean cv. Farah	**Number**	**Weight (mg)**
Nil	0	0
Peat slurry	8.33	65
Biostacked	7.22	64
TagTeam	5.42	75
Peat granules	2.63	43
Peat inject	0.50	8
LSD^	1.39	18
Lupin cv. Jindalee	**Number**	**Weight (mg)**
Nil	19.8	64
Peat slurry	19.7	69
Peat granules	15.5	55
Peat inject	26.8	74
LSD^	7.12	40

* This site suffered severe bird damage before harvest, therefore no crop yield data is available

^ LSD-Least significant differences indicate where statistically significant differences were observed

Growers can now choose different delivery methods and inoculation formulations. However, it is important to ensure the maximum economic return from the legume rotation with any selection.

The standard peat slurry on seed delivery method provides consistent results across a range of sites.

However, for growers seeking simpler inoculant delivery methods, the use of granular products could be more suitable.

While a direct benefit of co-inoculants was not seen in these trials, further testing is required to determine their appropriate place in Australian legume cropping systems.

A well-nodulated faba bean root system, Culcairn 2010.

Inoculation responses achieved in faba beans, Culcairn 2010. Note the colour difference between plots, indicating nitrogen deficiency in the uninoculated plot.

SPONSORS

Research funding was provided by the Grains Research and Development Corporation (GRDC) and the Department of Primary Industries through the National Rhizobium program.

We are very grateful to John Harris and Andrew Goode for providing the land at which the field sites were established.

CONTACT

David Pearce
DPI Victoria, Rutherglen
T: (02) 6030 4500
E: david.pearce@dpi.vic.gov.au

GOLDACRES
CHANGE THE WAY YOU SPRAY

The Evolution of Spraying

The all new *Prairie Evolution*
simply advanced

Build your sprayer

- DCI with Direct Draw
- Ultraglide
- SmartSteer
- 3TS
- Rapid Fire
- Rapidflow

Redefining spraying equipment

Goldacres has set the benchmark in spraying equipment for over 30 years, the advanced simplicity of the Prairie Evolution lifts the bar even higher with an all new EZ Control station, TriTech boom, and the most flexible range of tank sizes and options available so you can change the way you spray.

1-3 Morang Crescent, Mitchell Park Victoria 3355
Phone: 03 5342 6399-Fax: 03 5342 6308

www.goldacres.com.au

CHANGE THE WAY YOU SPRAY

North east Victoria National Variety Testing Trials 2010

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

During the 2010 trials the Dookie, Yarrawonga and Rutherglen wheat crops had half their replicates sprayed for stripe rust for comparison.

The oat and canola trials at Yarrawonga were disbanded due to waterlogging.

TABLE 1 Long-term predicted wheat yield (main season) for 2004–2010 in north east Victoria, and the number of site years in that area

Variety	Yield (t/ha)	Site years
Axe	3.09	16
Waagan	3.09	11
GBA Ruby	3.07	21
Bullet	3.06	9
Espada	3.06	13
Estoc	3.05	8
Gladius	3.04	16
GBA Hunter	3.04	5
Pugsley	3.03	19
Young	3.02	21
Correll	3.02	16
Spitfire	3.01	8
Magenta	2.95	9
Yitpi	2.95	17
Lincoln	2.94	11
Livingston	2.93	13
Derrimut	2.93	16
Catalina	2.92	13
Barham	2.92	16
Merinda	2.91	11
EGA Gregory	2.91	16
Guardian	2.91	8
Preston	2.91	6
Peake	2.89	16
Fang	2.89	3
Bowie	2.88	19
Orion	2.87	8
Beaufort	2.87	7
Yenda	2.86	14
Ventura	2.86	21
Tammarin Rock	2.86	10
Sentinel	2.84	18
Wyalkatchem	2.83	15
Frame	2.82	16
Giles	2.82	5
Janz	2.81	20
Bolac	2.79	13
Sunvex	2.77	5
EGA Wentworth	2.76	8
Annuello	2.75	10
Dakota	2.75	9
GBA Sapphire	2.73	8
Ellison	2.72	5
Whistler	2.71	5
Clearfield Jnz	2.70	5
EGA Wills	2.70	9
Kennedy	2.69	4
Crusader	2.69	9
Chara	2.69	21
SQP Revenue	2.68	4
Wylah	2.65	5
EGA Wylie	2.65	4
EGA Bounty	2.65	6
Rosella	2.59	19

TABLE 2 Long-term predicted wheat yield (long season) for 2004–2010 in north east Victoria, and the number of site years in that area

Variety	Yield (t/ha)	Site years
Preston	4.30	3
Beaufort	4.28	5
Bolac	4.02	6
Sentinel	3.85	6
SQP Revenue	3.83	5
EGA Gregory	3.83	7
Yenda	3.82	5
Endure	3.76	4
Mansfield	3.75	3
Barham	3.72	4
EGA Eaglehawk	3.71	5
EGA Wedgetail	3.67	7
Sunzell	3.63	4
EGA Bounty	3.59	3
Chara	3.56	7
Kellalac	3.51	7
Naparoo	3.49	3
Whistler	3.47	3
Amarok	3.40	3

TABLE 3 Yield and quality of wheat varieties during 2010 at Dookie (main season)

Variety	Sprayed yield (t/ha)	Hectolitre weight (kg/hl)	Protein (%)	Screenings <2.0 mm (%)	Seed size (g/1000 seeds)	Unsprayed yield (t/ha)
Scout	6.94	74.76	10.0	3.94	45.00	5.22
Orion	6.27	67.06	9.1	0.80	48.00	4.29
Clearfield Stl	6.22	74.76	10.0	2.54	42.30	4.66
Espada	6.07	70.22	11.2	2.13	45.40	4.61
Spitfire	5.81	77.57	10.7	4.88	45.60	5.03
Ventura	5.71	73.47	11.0	3.18	37.70	4.55
Frame	5.66	73.46	10.8	3.14	45.00	4.74
Estoc	5.61	74.35	11.2	3.27	42.20	4.61
Barham	5.46	71.70	10.4	1.48	42.80	3.76
Magenta	5.46	72.02	10.2	3.65	47.10	4.15
Correll	5.36	69.56	11.6	3.78	46.10	4.78
Young	5.20	73.69	11.0	2.13	38.40	4.55
GBA Ruby	5.10	72.64	11.6	3.80	42.30	4.78
Yitpi	5.10	72.33	11.0	4.41	45.30	4.97
EGA Gregory	5.05	74.00	10.1	3.30	44.30	4.50
Gladius	5.00	70.14	11.8	2.43	49.00	4.32
Chara	4.64	72.34	10.6	2.19	42.60	3.49
Derrimut	4.64	n/a	n/a	n/a	n/a	3.59
Catalina	4.59	74.57	11.3	1.97	43.60	3.64
SQP Revenue	4.49	70.94	8.4	3.58	39.60	4.06
Sentinel	4.44	n/a	n/a	n/a	n/a	4.50
Yenda	4.44	69.73	12.0	3.25	36.60	3.26
Bolac	4.28	71.80	11.1	3.61	36.50	3.89
Clearfield Jnz	4.18	73.38	11.7	1.58	43.30	3.59
Lincoln	4.18	72.60	10.1	5.26	46.50	3.66
Axe	4.03	72.24	12.5	2.38	45.30	3.63
Peake	3.77	73.72	10.9	2.68	42.50	3.28
Livingston	3.52	74.39	11.7	1.73	42.40	3.62
Sown	17 May 2010					17 May 2010
Harvested	29 December 2010					29 December 2010
Site mean (t/ha)	4.98					4.38
CV (%)	10.5					6.3
LSD (t/ha)	1.16					0.66

TABLE 4 Yield and quality of wheat varieties during 2010 at Wunghnu (main season)

Variety	Sprayed yield (t/ha)	Hectolitre weight (kg/hl)	Protein (%)	Screenings <2.0 mm (%)	Seed size (g/1000 seeds)
Sentinel	5.60	72.14	10.7	0.91	44.60
SQP Revenue	5.54	70.37	10.1	4.40	36.00
Espada	5.39	73.26	10.9	1.74	44.00
Scout	5.39	75.82	11.2	2.97	40.80
GBA Ruby	5.23	73.46	9.6	2.76	42.60
Gladius	5.23	72.70	11.0	3.32	41.50
Correll	5.13	71.52	10.9	3.30	44.20
Estoc	5.13	76.02	10.4	2.03	43.40
Bolac	5.07	72.67	10.3	7.47	29.30
EGA Gregory	5.07	76.44	10.3	2.07	44.70
Livingston	5.07	75.23	12.0	1.37	42.10
Lincoln	4.97	73.78	10.0	2.89	41.90
Spitfire	4.97	78.56	12.3	4.67	48.20
Axe	4.86	72.20	11.5	1.06	44.90
Yitpi	4.81	73.75	11.0	2.74	45.20
Chara	4.65	74.27	11.0	2.35	37.20
Catalina	4.60	76.22	11.1	1.57	43.50
Janz	4.55	74.95	10.5	2.13	37.20
Peake	4.50	73.79	9.9	2.56	38.70
Derrimut	4.18	73.41	10.4	3.05	35.60
Barham	4.13	70.34	10.3	1.65	37.30
Clearfield Jnz	4.08	54.93	11.1	1.33	40.60
Young	4.08	73.75	11.6	2.73	34.80
Magenta	4.03	73.32	10.0	2.65	39.00
Frame	3.97	73.92	10.8	3.73	43.70
Clearfield Stl	3.87	74.69	10.0	3.01	35.50
Yenda	3.87	68.24	10.6	7.41	28.40
Orion	3.82	67.29	8.9	1.30	40.50
Ventura	3.82	73.95	10.2	2.89	41.00
Kennedy	3.71	73.09	10.6	1.29	40.40
Beaufort	3.19	72.29	10.2	2.98	39.50
Sown	**7 June 2010**				
Harvested	**28 December 2010**				
Site mean (t/ha)	**4.78**				
CV (%)	**5.39**				
LSD (t/ha)	**0.43**				



TABLE 5 Yield and quality of wheat varieties during 2010 at Yarrawonga (main season)

Variety	Sprayed yield (t/ha)	Hectolitre weight (kg/hl)	Protein (%)	Screenings <2.0mm (%)	Seed size (g/1000 seeds)	Unsprayed yield (t/ha)
Beaufort	4.55	71.63	10.0	4.02	38.90	3.68
Orion	4.33	65.60	10.2	1.97	37.70	2.73
SQP Revenue	4.22	50.50	9.7	5.89	37.00	4.36
Estoc	4.00	74.93	12.4	2.34	42.10	3.22
Chara	3.77	73.94	11.2	1.79	39.60	2.26
Derrimut	3.77	73.35	11.2	2.89	33.70	1.83
Barham	3.75	70.91	10.9	1.55	36.80	2.07
Spitfire	3.69	78.47	11.1	3.00	46.80	3.92
Yenda	3.54	68.99	11.1	3.91	32.60	1.37
Correll	3.52	70.24	11.8	4.50	42.80	2.90
Janz	3.45	74.87	10.8	2.54	44.20	2.25
Clearfield Stl	3.34	75.14	10.9	3.15	37.40	1.34
Ventura	3.24	72.40	11.4	3.50	36.80	2.43
Yitpi	3.20	73.78	10.9	3.97	47.80	2.76
Frame	3.19	73.56	11.5	3.26	42.30	2.41
Lincoln	3.19	74.14	10.8	3.25	43.60	2.77
Bullet	3.15	72.30	10.5	2.83	35.10	2.02
Catalina	3.14	75.53	11.6	1.51	41.70	2.46
EGA Gregory	3.09	76.25	10.6	2.22	40.30	2.54
Livingston	3.05	75.64	11.9	1.19	41.30	2.74
Bolac	2.95	72.51	11.3	6.26	30.10	2.27
Espada	2.94	71.62	11.2	2.64	41.80	2.47
Young	2.94	71.14	12.2	4.61	30.70	1.89
Peake	2.74	73.02	11.9	3.13	35.20	2.01
Scout	2.64	75.87	11.0	2.57	41.40	1.58
Clearfield Jnz	2.34	75.30	11.4	1.41	39.90	1.53
Sentinel	2.16	72.10	10.6	1.39	43.10	1.70
Gladius	1.89	70.77	11.6	2.21	43.70	1.34
Magenta	1.84	72.64	11.7	5.22	36.80	1.56
Kennedy	1.83	71.85	11.6	2.75	37.40	1.32
Axe	1.66	71.24	13.1	2.65	40.00	1.19
GBA Ruby	1.66	73.44	10.7	3.04	39.80	1.40
Sown	**27 May 2010**					**27 May 2010**
Harvested	**6 January 2011**					**6 January 2011**
Site mean (t/ha)	**2.94**					**2.23**
CV (%)	**9.95**					**8.6**
LSD t/ha	**0.59**					**0.43**

TABLE 6 Yield and quality of wheat varieties during 2010 at Rutherglen (long season)

Variety	Sprayed yield (t/ha)	Hectolitre weight (kg/hl)	Protein (%)	Screenings <2.0mm (%)	Seed size (g/1000 seeds)	Unsprayed yield (t/ha)
Preston	6.16	65.86	9.8	0.86	43.20	5.47
Orion	5.92	62.25	9.5	0.76	48.00	4.38
Mansfield	5.33	65.52	10.5	2.62	36.30	4.27
SQP Revenue	5.23	68.30	9.8	2.24	48.70	4.72
Beaufort	5.13	68.69	9.3	3.27	42.00	3.95
Derrimut	4.99	70.59	11.8	0.77	41.20	3.26
Bolac	4.94	65.29	11.4	1.83	34.70	4.62
Estoc	4.94	70.75	12.9	1.30	43.90	4.06
Kellalac	4.89	70.10	11.0	1.07	39.80	3.43
Endure	4.55	68.94	11.9	0.74	39.90	4.05
Yenda	4.55	65.67	10.3	1.17	39.40	2.76
Espada	4.50	66.57	10.7	0.94	46.70	3.64
EGA Wedgetail	4.35	63.37	12.1	0.99	44.80	3.66
Chara	4.30	67.60	11.1	0.73	39.80	4.07
Barham	4.25	65.99	11.5	1.07	40.80	3.23
EGA Bounty	4.16	66.95	11.2	0.54	45.60	3.92
Kennedy	3.91	64.16	11.6	0.68	43.70	2.40
EGA Gregory	3.52	70.65	10.6	0.98	42.60	3.72
Sentinel	3.42	66.61	11.2	0.65	47.00	3.48
Sown	12 May 2010					12 May 2010
Harvested	21 January 2011					21 Jan 2011
Site mean (t/ha)	4.54					3.83
CV (%)	9.1					9.7
LSD (t/ha)	0.97					0.89

TABLE 7 Long-term predicted triticale yield for 2004–2010 in north east Victoria and the number of site years in that area

Variety	Yield (t/ha)	Site years
Bogong	3.03	8
Canobolas	3.00	8
Berkshire	2.93	8
Hawkeye	2.85	10
Jaywick	2.84	10
Tobruk	2.82	10
Chopper	2.80	6
Crackerjack	2.70	4
Rufus	2.67	6
Tahara	2.57	12
Tickit	2.54	5
Abacus	2.44	4
Tuckerbox	2.40	4
Credit	2.37	5
Speedee	2.27	4
Kosciuszko	2.12	6



TABLE 8 Yield of triticale varieties during 2010 at Rutherglen

Variety	Sprayed yield (t/ha)	Hectolitre weight (kg/hl)	Protein (%)	Screenings <2.0mm (%)	Seed size (g/1000 seeds)	Height (cm)
Crackerjack	5.36	65.32	10.2	0.62	46.30	128.5
Tobruk	5.17	67.18	10.2	1.56	50.40	123.5
Canobolas	4.97	67.50	10.3	3.24	51.30	117.5
Bogong	4.88	69.32	10.5	0.86	50.70	115.7
Chopper	4.88	59.95	10.8	1.77	45.10	100.0
Jaywick	4.70	64.74	10.4	1.27	49.90	116.7
Rufus	4.59	63.41	10.8	0.56	48.70	128.0
Berkshire	4.55	65.87	10.9	2.39	50.40	116.0
Hawkeye	4.39	65.58	10.7	0.79	48.10	115.0
Tuckerbox	4.18	62.06	9.5	0.07	41.80	119.0
Tahara	4.13	62.86	10.4	0.81	42.00	117.5
Yowie	3.65	63.30	10.7	0.97	45.50	114.3
Sown	**9 June 2010**					
Harvested	**21 January 2011**					
Site mean (t/ha)	**4.53**					
CV (%)	**6.5**					
LSD (t/ha)	**0.56**					

TABLE 9 Yield of triticale varieties during 2010 at Yarrawonga

Variety	Sprayed yield (t/ha)	Hectolitre weight (kg/hl)	Protein (%)	Screenings <2.0mm (%)	Seed size (g/1000 seeds)	Height (cm)
Berkshire	4.39	65.87	11.7	4.41	42.40	127.0
Hawkeye	4.37	64.88	11.7	1.73	43.60	124.3
Bogong	4.34	67.84	11.1	3.96	42.40	128.8
Chopper	4.10	59.78	11.3	2.94	30.60	98.5
Jaywick	4.07	65.41	10.6	3.07	44.40	121.7
Yowie	3.70	62.91	11.2	2.01	41.20	120.3
Canobolas	3.64	66.85	11.3	6.17	45.40	124.0
Rufus	3.63	63.56	12.2	3.81	40.60	127.0
Tobruk	3.58	66.35	10.8	6.06	41.10	130.8
Tahara	3.50	62.56	11.9	2.35	43.50	125.8
Tuckerbox	3.29	61.79	11.8	3.97	29.20	128.3
Crackerjack	2.42	60.74	11.6	4.84	32.80	138.0
Sown	**31 May 2010**					
Harvested	**7 January 2011**					
Site mean (t/ha)	**3.78**					
CV (%)	**5.4**					
LSD (t/ha)	**0.31**					

TABLE 10 Long-term predicted barley yield for 2004–2010 in north east Victoria and the number of site years in that area

Variety	Yield (t/ha)	Site years
Fleet	3.68	5
Lockyer	3.66	3
Hindmarsh	3.65	6
Commander	3.59	7
Capstan	3.58	7
Yarra	3.55	7
Keel	3.54	6
Fitzroy	3.52	4
Buloke	3.47	7
Vlamingh	3.44	4
Hannan	3.44	3
Macquarie	3.43	4
Gairdner	3.36	7
Baudin	3.31	7
Flagship	3.30	7
Schooner	3.11	7
Franklin	3.07	6
Finniss	3.06	5

TABLE 11 Predicted yield and quality of barley varieties during 2010 at Katamatite

Variety	Yield (t/ha)	Hectolitre weight (kg/hl)	Protein (%)	Screenings <2.0mm (%)	Plumpness >2.5mm (%)	Seed size (g/1000 seeds)	Height (cm)
Oxford	5.34	60.86	8.9	1.2	96.2	43.30	58.3
Macquarie	4.79	60.77	9.6	1.9	94.4	48.90	75.0
Capstan	4.76	57.81	9.9	1.5	94.2	46.70	44.0
Commander	4.70	61.83	9.4	1.2	97.1	47.50	72.0
Westminster	4.53	62.59	8.9	0.9	98.4	51.30	69.0
Fairview	4.47	62.70	8.9	0.5	98.2	49.70	58.3
Yarra	4.43	59.55	10.0	0.7	98.3	52.10	57.7
Fleet	4.41	56.18	10.1	0.8	98.0	56.20	79.0
Hindmarsh	4.32	62.33	9.7	1.0	97.3	44.10	68.0
Vlamingh	4.31	62.42	11.3	0.6	98.4	46.30	74.7
Gairdner	4.26	60.92	9.5	1.0	97.0	48.10	75.7
Buloke	4.24	60.60	10.9	0.7	97.8	52.70	81.3
Baudin	3.98	62.50	9.9	0.5	98.8	46.80	53.3
Flagship	3.86	58.95	9.2	1.6	96.9	48.50	80.7
Finniss	3.61	64.74	10.5	2.4	83.4	45.10	53.3
Schooner	3.59	61.74	9.8	0.8	97.8	47.10	85.0
Scope	3.57	61.44	10.1	0.9	97.6	53.00	84.7
Sown	7 June 2010						
Harvested	12 December 2010						
Site mean (t/ha)	4.32						
CV (%)	5.7						
LSD (t/ha)	0.39						



TABLE 12 Long-term predicted oat yield for 2004–2010 in north east Victoria and the number of site years in that area

Variety	Yield (t/ha)	Site years
Quoll	2.37	8
Potoroo	2.31	9
Echidna	2.31	7
Possum	2.28	10
Mitika	2.26	10
Kojonup	2.22	5
Yallara	2.15	10
Euro	2.11	10
Mortlock	1.85	8
Numbat	1.44	3

TABLE 13 Yield of oat varieties during 2010 at Dookie

Variety	Yield (t/ha)	Hectolitre weight (kg/hl)	Protein (%)	Screenings <2.0mm (%)	Seed Size g/1000 seeds	Height (cm)
Yallara	2.69	46.61	9.7	2.50	39.10	109.3
Quoll	4.23	46.42	10.2	2.68	47.00	91.0
Possum	2.94	41.93	10.5	6.48	44.20	82.0
Numbat	2.54	48.00	9.3	14.32	30.50	80.5
Mitika	2.52	47.58	9.9	9.76	36.10	71.0
Euro	2.63	44.99	9.7	4.34	42.00	100.0
Sown	17 May 2010					
Harvested	30 December 2010					
Site mean (t/ha)	2.97					
CV (%)	10.8					
LSD (t/ha)	0.47					

TABLE 14 Long-term predicted yield for conventional canola for 2004–2010 in north east Victoria and the number of site years in that area

Variety	Yield (t/ha)	Site years
AV Garnet	1.37	4
Hyola 50	1.36	4
Monola 130CC	1.10	4
Pioneer 46Y78	1.10	3
RocketCL	0.90	3

TABLE 15 Yield of conventional canola varieties during 2010 at Wunghnu (mid season)

Variety	Yield (t/ha)	Oil (%)	Protein (%)	Height (cm)	50% Flowering year day
AV Garnet	2.63	46.6	36.8	135.0	232.33
CB Agamax	2.09	46.7	34.9	130.7	232.67
Hyola 433	2.52	46.5	36.2	131.3	231.33
Hyola 50	2.73	47.4	36.2	135.3	236.67
Victory V3001	1.99	44.4	35.9	129.3	229.67
Sown	5 May 2010				
Harvested	24 November 2010				
Site mean (t/ha)	2.46				
CV (%)	9.6				
LSD (t/ha)	0.36				

TABLE 16 Long-term predicted yield of imidazolinone tolerant (imi) canola for 2004–2010 in north east Victoria and the number of site years in that area

Variety	Yield (t/ha)	Site years
Pioneer 44Y84	1.58	5
Pioneer 46Y83	1.52	5
Pioneer 45Y82	1.50	5
Hyola 571CL	1.46	5
Pioneer 46Y78	1.42	7
Pioneer 45Y77	1.37	5
Pioneer 44C79	1.23	3

TABLE 17 Yield and quality of imidazolinone tolerant (imi) canola varieties during 2010 at Wunghnu (mid season)

Variety	Yield (t/ha)	Oil (%)	Protein (%)	Height (cm)	50% Flowering year day
Hyola 571CL	2.17	46.7	35.2	135.7	230.33
Pioneer 44Y84	2.15	48.9	34.9	138.7	233.33
Pioneer 46Y83	1.88	n/a	n/a	145.3	236.00
Hyola 676CL	1.77	48.4	36.2	151.3	237.67
Hyola 575CL	1.75	47.0	35.4	152.3	239.33
Pioneer 45Y82	1.63	45.8	35.4	132.7	231.33
Pioneer 46Y78	1.62	48.2	34.9	153.0	238.67
Sown	5 May 2010				
Harvested	24 November 2010				
Site mean (t/ha)	1.81				
CV (%)	10.4				
LSD (t/ha)	0.31				

TABLE 18 Yield and quality of imidazolinone tolerant (imi) canola varieties during 2010 at Dookie (mid season)

Variety	Yield (t/ha)	Oil (%)	Protein (%)	50% Flowering year day
Hyola 571CL	2.52	45.0	39.1	231.00
Hyola 575CL	2.34	45.9	40.6	241.00
Hyola 676CL	2.65	46.5	40.4	244.00
Pioneer 44Y84	2.76	46.6	40.1	237.33
Pioneer 45Y82	2.49	46.0	37.4	232.00
Pioneer 46Y78	2.46	45.5	40.0	243.33
Pioneer 46Y83	2.52	37.2	47.1	240.33
Sown	5 May 2010			
Harvest	30 November 2010			
Site mean (t/ha)	2.51			
CV (%)	6.7			
LSD (t/ha)	0.27			

TABLE 19 Long-term predicted yield of mid season triazine tolerant (TT) varieties for 2004–2010 in north east Victoria and the number of site years in that area

Variety	Yield (t/ha)	Site years
CB Jardee HT	1.47	5
CB Tumby HT	1.39	5
ATR Cobbler	1.37	7
Monola 76TT	1.37	5
Monola 77TT	1.37	5
BravoTT	1.34	8
Tawriffic TT	1.34	7
Hurricane TT	1.33	3
ATR409	1.32	6
Rottnest TTC	1.32	5
ThunderTT	1.32	5
ATR Barra	1.29	3
CB Scaddan	1.28	5
ATR Marlin	1.27	6
CB Telfer	1.25	5
Lightning TT	1.25	3
CB Tanami	1.24	5
CB Argyle	1.23	7

TABLE 20 Yield and quality of triazine tolerant (TT) canola varieties during 2010 at Wunghnu (mid season)

Variety	Yield (t/ha)	Oil (%)	Protein (%)	Height (cm)	50% Flowering year day
CrusherTT	2.19	47.0	34.2	134.0	239.67
Tawriffic TT	2.17	49.9	35.1	140.0	231.67
ATR Snapper	2.14	51.6	32.1	124.7	236.67
Monola 76TT	2.13	50.1	35.0	130.7	236.00
Hyola 555TT	2.12	46.7	36.3	127.3	239.33
ATR Stingray	2.05	49.3	35.8	114.0	232.00
Monola 77TT	2.02	50.5	34.4	125.7	239.00
Thumper TT	2.01	48.8	35.6	118.7	240.67
CB Tumby HT	2.01	46.9	34.2	136.0	234.33
CB Jardee HT	1.94	47.0	33.5	139.3	239.33
Fighter TT	1.93	46.9	37.2	115.7	239.33
ATR Cobbler	1.90	48.0	35.6	124.3	233.33
Monola 603TT	1.88	50.9	34.6	126.7	239.00
CB Argyle	1.87	49.9	36.3	117.7	240.67
Hyola 444TT	1.86	48.1	39.6	121.3	238.67
CB Mallee HT	1.86	45.9	34.7	140.0	233.33
CB Telfer	1.83	48.3	36.8	119.3	223.67
CB Scaddan	1.72	46.3	34.6	144.7	233.33
Monola 704TT	1.69	50.9	34.6	128.0	237.00
CB Tanami	1.40	45.4	36.0	117.7	226.00
Sown	5 May 2010				
Harvested	24 November 2010				
Site mean (t/ha)	1.94				
CV (%)	6.7				
LSD (t/ha)	0.21				

TABLE 21 Yield and quality of triazine tolerant (TT) canola varieties in 2010 at Dookie (mid season)

Variety	Yield (t/ha)	Oil (%)	Protein (%)	50% Flowering year day
Hyola 751TT	3.28	46.4	39.8	240.67
CB Junee HT	3.21	44.5	38.3	234.67
CrusherTT	2.99	45.1	39.2	240.00
Hyola 555TT	2.99	44.6	43.1	239.00
Thumper TT	2.89	46.3	42.4	239.67
CB Tumby HT	2.87	46.3	38.4	237.67
CB Jardee HT	2.78	44.7	39.7	240.25
Monola 77TT	2.74	47.8	41.7	237.67
ATR Stingray	2.70	45.5	42.2	233.67
ATR Snapper	2.67	49.5	39.8	236.00
Fighter TT	2.67	45.7	40.5	238.67
Tawriffic TT	2.58	48.5	40.4	233.50
Monola 76TT	2.57	47.7	40.9	237.00
Monola 704TT	2.52	49.1	40.0	236.33
Hyola 444TT	2.46	45.0	43.5	235.00
Monola 603TT	2.41	48.4	40.7	237.33
CB Mallee HT	2.40	45.6	39.5	235.00
CB Scaddan	2.28	43.9	39.6	237.00
ATR Cobbler	2.21	45.8	40.2	236.00
CB Argyle	2.13	46.7	43.9	239.33
CB Telfer	2.09	47.1	41.0	224.00
CB Tanami	1.62	43.0	40.7	224.67
Sown	5 May 2010			
Harvested	3 December 2010			
Site mean (t/ha)	**2.56**			
CV (%)	**10.4**			
LSD (t/ha)	**0.49**			

TABLE 22 Long-term predicted yield of faba bean varieties for 2004–2010 in north east Victoria and the number of site years in that area

Variety	Yield (t/ha)	Site years
Fiesta VF	1.90	7
Farah	1.90	7
Cairo	1.85	5
Nura	1.83	7
Fiord	1.81	6
Doza	1.71	4
Manafest	1.65	4

TABLE 23 Yield and quality of faba bean varieties during 2010 at Katamatite

Variety	Yield (t/ha)	Seed size (g/1000 seeds)
Fiesta VF	0.94	48.00
Doza	1.07	44.00
Farah	1.64	49.00
Nura	2.02	59.00
Sown	10 May 2010	
Harvested	24 January 2011	
Site mean (t/ha)	**1.61**	
CV (%)	**13.9**	
LSD (t/ha)	**0.36**	

TABLE 24 Long-term predicted yield of lupin varieties for 2004–2009 in north east Victoria and the number of site years in that area

Variety	Yield (t/ha)	Site years
Danja	2.20	6
Jindalee	2.30	7
Moonah	2.31	7
Tanjil	2.33	4
Wonga	2.33	7
Quilinock	2.41	5
Belara	2.41	5
Mandelup	2.49	7

TABLE 25 Yield and quality of lupin varieties in 2010 at Elmore

Variety	Yield (t/ha)	100 seed weight (g/100 seeds)
Mandelup	4.09	17.42
Jenabillup	3.93	15.80
Coromup	3.71	18.22
Wonga	3.48	14.64
Sown	7 May 2010	
Harvested	24 December 2010	
Site mean (t/ha)	**3.99**	
CV (%)	**6.1**	
LSD (t/ha)	**0.4**	



2010 nutrition review — following high-yielding crops

Matthew Sparke [1] **and Rob Norton** [2]
[1] Dodgshun Medlin Agricultural Management
[2] International Plant Nutrition Institute

Key points

- Wheat crops remove about three kilograms of nutrients per tonne of grain and canola removes about 5kg/t.
- Phosphorus (P) rates for 2011 will need to at least replace that removed during 2010.
- The wet 2010 may have leached the more mobile nutrients, such as nitrogen (N), sulphur (S) and potassium (K) deeper into the profile. This suggests that at sowing, rates may need to be increased for these nutrients to ensure they remain at adequate levels in the developing root zone.
- Soil profiles will contain good soil water stores this year and to use this water, adequate and balanced nutrition at sowing will be important.
- Soil testing, although far from perfect, remains the best method to assess nutrient supply to guide fertiliser application rates. Assessing subsoil nutrient supply, particularly of nitrogen and sulphur, will be important to understand the potential subsoil nutrient supply in a wet profile and to ensure nutrients are supplied at the right time.
- Getting the right nutrient source at the right rate, right time and right place is the basis of sound nutrient management.

Sound crop nutrition is part of a whole agronomy package and cannot — or should not — be considered in isolation from soil type, region, paddock preparation, crop type or variety, crop protection, equipment available, the yield potential and other agroclimatic issues.

An effective nutrition program will look to at least maintain soil fertility which links closely with soil physical and biological health. Such a program will look to supply what is required to meet the productivity expected and attempts to balance risk and return.

During the past decade, due to seasonal conditions and high prices, fertiliser use in Victoria has declined by about 14% for nitrogen and 44% for phosphorus compared with the decade average. While this is a response to lower yields, 2011 is a time to review these strategies in order to look at the way seasonal opportunities can be grasped.

During 2010, rainfall provided the opportunity for substantial yields. Although weather damage during harvest took the gloss away, yields and therefore nutrient removals were higher than those seen for a decade (see Table 1). Note: Take care when analysing these nutrient removal figures as there are large site differences — for example, an International Plant Nutrition Institute (IPNI) survey of National Variety Trial (NVT) grain nutrient densities showed that wheat grain phosphorus content can vary from 2.5 to 4kg/t.

Review of nutrient investments made during 2010

Every grower knows what they spend on nutrition. For example, Mallee wheat growers invest about $50–$90/ha, for about 6kg of phosphorus ($16), zinc ($4) and then nitrogen ($27–$45/ha).

In the Wimmera, with a higher frequency of pulses, that investment could be 10kg of phosphorus ($27), zinc ($4) and nitrogen ($45).

Fertiliser cost per hectare could be well above $120 in the higher-rainfall regions.

TABLE 1 Approximate nutrient removals* by major grain crops

Crop type (yield and protein)	Nitrogen (kg/ha)	Phosphorus (kg/ha)	Potassium (kg/ha)	Sulphur (kg/ha)
Wheat (5t/ha, 12%)	105	15	18	6
Canola (3t/ha, 23%)	90	15	20	15
Barley (5t/ha, 10%)	90	15	23	6

*Nutrient densities are taken from Reuter & Robinson, 1997

Sulphur is somewhat overlooked and less managed except in canola and on sand rises, where sulphate of ammonia (SOA) is the product of choice.

Zinc is often used only in good seasons, and there are areas where copper and potassium could also have been overlooked.

Most growers would use 6–10kg/ha of phosphorus in the Wimmera and 15kg/ha in south-west and north-east Victoria. Typically, growers now gear nitrogen applications around yield expectations, with rates from nil to 150kg/ha.

Phosphorus investments

The Dahlen Incitec Pivot long-term fertiliser site gives some insights for phosphorus balance (see Figure 1). For instance, applying 9kg/ha of phosphorus per crop during the past 15 years has kept Colwell P at about 25mg/kg (with a slight positive phosphorus balance). That is, input (9kg of applied phosphorus) and output (3t/ha wheat equivalent to 9kg phosphorus) are about equal. But during 2010 phosphorus off-take has been two to three times the long-term average. The implication is that soil test values will decline and paddocks with large off-takes will give a larger (but still moderate) response to phosphorus during 2011.

Nitrogen investments

Interpreting nitrogen removal can also help when evaluating past fertiliser strategies. For example, from the Longerenong Canola Challenge, the amount of nitrogen remaining can be estimated. Table 2 gives the data for some of the higher-yielding crops.

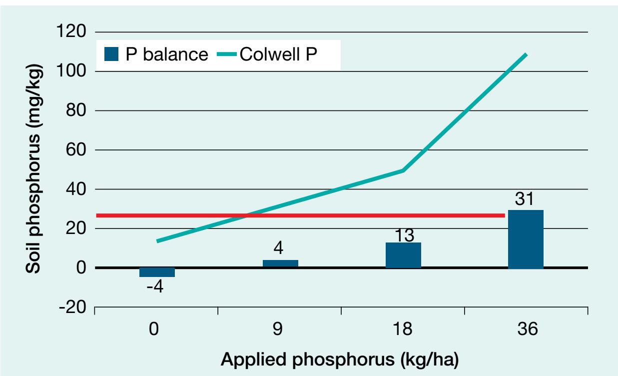


FIGURE 1 Colwell soil P value and phosphorus balance 1996–2007
*The red line is the phosphorus soil test value at the start of the experiment

Interpreting the data would be meaningless unless soil test values (starting nitrogen and soil carbon (C)) were available. Soil tests have some problems but they do provide information to consider within the whole decision-making framework.

Tools such as Yield Prophet® can help growers review water limited crop potential and match nitrogen to that potential.

Other nutrient investments

Sulphur — as discussed, growers often overlook and under-manage sulphur except in canola and on sand rises.

When used, SOA is a better sulphur source than gypsum for canola (see Figure 2).

Zinc — grain zinc content is a potential indicator of zinc response. Grain zinc levels are generally lower on alkaline soils and poor grain zinc can also contribute to poor crop establishment.

Copper — copper deficiency was seen during 2010, probably as a result of the better growing conditions which resulted in a higher demand for copper.

Potassium — potassium responses have also been reported in unexpected areas, such as the Mallee. Deficiencies have been seen on light soils in wet years and where hay has been cut. These are situations where there is high leaching, high demand and low potential supply.

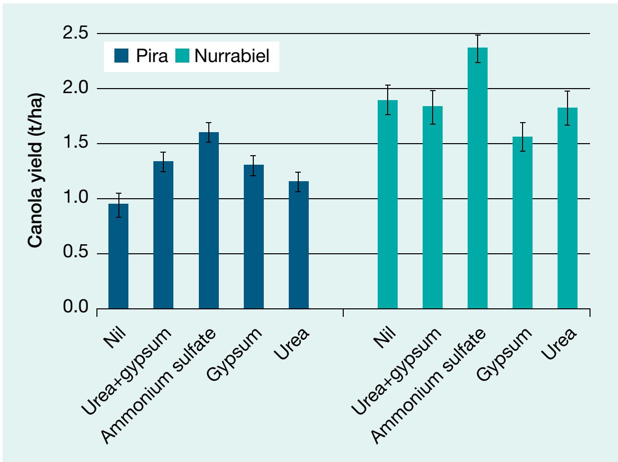


FIGURE 2 Response of canola to various nitrogen and sulphur sources in Western Victoria, 2009

TABLE 2 Apparent nitrogen budgets for Longerenong Canola Challenge, 2010

Team name	Canola yield (t/ha)	Soil test nitrogen (kg/ha)	Applied nitrogen (kg/ha)	In-season mineralisation (kg/ha)	Nitrogen removed (kg/ha)	50% nitrogen use efficiency (NUE)	Nitrogen balance (kg/ha)
Longy Lecturers	2.77	160	41	60	111	221	39
Raging Reds	3.47	160	40	60	139	278	-18
BCG	2.67	160	0	60	107	213	7



Assessing fertiliser investments — tools of the trade

1. **Test strips** — Growers often raise questions regarding the return on their investment or the merits of using an extra 40kg/ha of nitrogen on canola during 2011. There are few tools available to review the past season's fertiliser strategy. Some advisors suggest checker-board trials, omission strips or grain nutrient levels. If the decision is made to set up test strips or omission plots, make sure they are big enough to show up on a yield map so a final assessment can be made. During the season, these plots can be used as a reference to check if a response to treatment occurs or if more fertiliser is needed. If using optical sensors (such as 'Greenseeker'®) a nitrogen-rich strip will be required for calibration.
2. **Grain protein levels** — Grain nitrogen removal is a reasonable measure of nutrient demand, and growers can use grain protein content as a post-harvest assessment of how well nitrogen supply was matched to yield potential (water supply). Some on-the-go protein sensors and yield maps make it possible to derive nitrogen removal maps for a paddock.
3. **Nutrient ratios** — other nutrient relationships can also be used to assess balanced nutrition, and grain N:S ratio (related to protein quality) and which is affected by relative nitrogen and sulphur supply. Using data from the 2009 NVT grain protein analyses, IPNI derived Figure 3 showing N:S ratios — an imbalance exists where wheat grain sulphur is less than 1200mg/kg and the ratio of N:S is higher than 17:1. This also gives a benchmark for matching sulphur to nitrogen supply. There are similar interpretations for canola which has a lower critical N:S ratio.

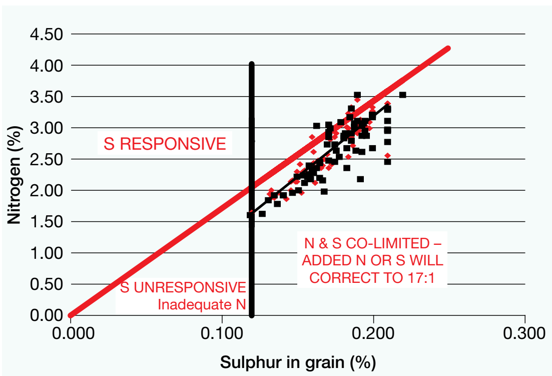


FIGURE 3 Relationship between nitrogen and sulphur levels in wheat grain, taken from the 2009 NVT grain nutrient analyses (IPNI, 2010)

Looking forward — the four Rs of fertilser management

Based on what has happened during 2010, we can expect soil profiles to be full and yield potentials high, although it is important to remain realistic about target yields. Summer weed control will be vital to ensure water was conserved for the crop.

Gear a nutrition program towards supporting better-than-average yields from the start and nitrogen and phosphorus will be the big-ticket items to get right before considering other inputs.

Concentrate fertiliser investments on the best paddocks and the most profitable crops.

Use the four Rs of fertiliser management — *right* nutrient source at the *right* rate, *right* time and *right* place.

Right products (source) — There are new products entering the market and advisers are reminded to take the data presented with a healthy skepticism. Products with claims that are too good to be true are just that — not true. The bottom line is to look for a couple of years of field testing in similar environments, with yield data presented that has some measure of error or statistical analysis. Check carefully the price and reduce price to the cost per kilogram of nutrient delivered to the crop.

Right rate — Soil test values are not all the same in an area and testing a correctly-collected representative soil sample is still an effective way to get information about the general responsiveness to nitrogen, phosphorus and sulphur for a given paddock. Although far from perfect, topsoil (0–10cm) phosphorus will provide a general starting point for crop nutrition decisions.

For nitrogen and sulphur, use a deep soil test and aim to meet target yields by supplementing with fertilisers on top of what is on offer from the soil.

Right time — The wet conditions are also likely to have leached mobile nutrients to below the rootzone or even cause nitrogen losses due to waterlogging. A direct consequence of this is that more nitrogen and sulphur will be required early in crop growth and less will be available in the upper parts of the rootzone. After 10 years of moving away from up-front nitrogen, maybe now is the time to revisit this strategy and put at least 30% of the target nitrogen requirement at sowing.

Right place — Despite some theoretical interest in foliar applied phosphorus, it is still important to apply phosphorus to the soil using rates that will at least replace P removal. Soil-applied phosphorus is the most available source for germinating seeds. Fertiliser phosphorus also provides a carrier for other materials, such as trace elements and fungicides, improving logistics for delivery of these products.

If moving towards higher fertiliser rates at sowing, take care with fertiliser and seed contact, especially with urea and canola. The sowing system used, the fertiliser applied and the crop selected will all dictate how close seed and fertiliser can be placed. Seedbed utilisation indices can be of use here, and damage will be worst with wide rows, minimum disturbance, and high salt index or highly alkaline fertilisers.

Consider the strategy to adopt with at-sowing fertiliser placement within the context of available machinery. This should include sowing configuration, points used and the number of boxes available.

Another confounding factor for 2011 is the stubble loads left from 2010 and this can mean more nitrogen tie-up, although some soil disturbance can help mineralisation.

Put tests strips in place, monitor paddock fertility and grain nutrient levels in the short and long-term, and keep accurate records of the complete costs of strategies used and the data used to make the decisions in 2011. Critically evaluate these decisions after the 2011 harvest is finished.

To find out more about the 4Rs approach, visit www.ipni.net/4r

CONTACT
Matt Sparke
E: matthew.sparke@dodgshunmedlin.com.au
Rob Norton
E: rnorton@ipni.net



Phosphorus management on high-phosphorus soils in the Lockhart district of southern New South Wales

Mark Harris
Rural Management Strategies Pty Limited

Key points

- No yield response occurred in wheat to applied phosphorus (P) on soils with a Colwell P level higher than 35mg/kg during 2009 and 2010.
- An application of 10kg of phosphorus (45kg/ha MAP) maintained the existing soil phosphorus level.
- Phosphorus replacement calculations can be modified to 'run-down' high soil phosphorus levels.

Aim

Investigate if existing soil phosphorus critical values are valid when using a knife point, press wheel, inter-row sowing system on soils with high Colwell P levels.

Observe the effect of reduced phosphorus application on the soil phosphorus bank.

Method

Six sites with Colwell P levels higher than 35mg/kg were established on varying soil types at Collingullie, Lockhart, Milbrulong, Osborne and Urana (two sites). Four sites were a continuation of a trial carried out during 2009.

A randomised block trial design using three replicates of four treatments was used to allow for statistical analysis of the data. The four treatments were 0kg/ha, 5kg/ha, 10kg/ha and 20kg/ha of phosphorus.

Trials were sown using the knife point, press wheel, inter-row sowing system within the recommended sowing window. The trials were harvested using GPS yield monitoring equipment and the raw data was cleaned before statistical analysis.

Results

Results from the trial sites are shown in Tables 1 and 2.

Observations and comments

The 5, 10 and 20kg/ha of phosphorus plots showed no visual difference, however the nil phosphorus treatment (0kg/ha) was always obvious due to less biomass.

No statistically significant yield response occurred to applied phosphorus at six of the eight sites across two years (data was not obtained for one site during 2009 and one site during 2010).

The response during 2009 at Collingullie was only significant for the 20kg phosphorus treatment and was a sowing date response. The Urana 2 site response was a result of soil acidity affecting soil phosphorus uptake.

Not applying phosphorus was the most economic treatment across the two years of the trial, however this approach depleted the soil phosphorus bank the most. The nil phosphorus plots fell below the critical Colwell P level of 35mg/kg after two years — they would respond to applied phosphorus during 2011.

The 5kg/ha phosphorus plots remained above the critical Colwell P level. The 10kg/ha treatment maintained soil

TABLE 1 Wheat yield for phosphorus treatments for 2009 and 2010

Phosphorus application rate (kg/ha)	Yield t/ha									
	Collingullie		Lockhart		Milbrulong		Osborne		Urana (site 1)	Urana (site 2)
	2009	2010	2009	2010	2009	2010	2009	2010	2010	2010
	Wheat	Wheat	Wheat	Wheat	Wheat	Wheat	Wheat	Canola	Wheat	Wheat
0	2.15	4.49	1.80	4.55	2.53	-	-	1.19	3.87	3.17
5	2.21	4.53	1.78	4.69	2.68	-	-	1.11	3.91	3.29
10	2.23	4.44	1.86	4.68	2.74	-	-	1.08	3.91	3.47
20	2.31	4.59	1.78	4.72	2.68	-	-	0.97	3.95	3.62
Significant difference		NSD	NSD	NSD	NSD			NSD	NSD	
LSD (P = 0.05)	0.088									0.107
CV (%)	1.99	4.03	3.32	1.38	4.25			8.80	2.97	1.59

TABLE 2 Two-year soil phosphorus balance 2009 and 2010 (wheat only)

Phosphorus applied (kg/ha)	Phosphorus removed (kg/ha)	Phosphorus balance (kg/ha)
0	22.5	-22.5
5	23.0	-13.0
10	23.3	-3.3
20	23.6	+16.4

phosphorus levels across the two years (see Table 2 and Figure 1).

The 20kg/ha treatment significantly increased the soil phosphorus bank. The phosphorus removed through grain yield from any plot in this treatment was consistently less than 20kg/ha.

In a high-yielding year (2010) with high soil phoshorus levels, no yield penalty existed from not applying phosphorus or applying low rates of phosphorus.

Soil phosphorus levels did not drop off rapidly after one high-yielding year. The soil phosphorus level reduced at a rate of 3.7mg/kg Colwell P per tonne of grain. On average, the nil phosphorus treatment saw soil phosphorus fall by 15mg/kg Colwell P with a 4.03t/ha grain yield.

The risk of 'missing out on a good year' from not applying enough phosphorus at sowing is low to nil when soil phosphorus levels are above 35mg/kg Colwell P, phosphorus buffering index (PBI) is less than 100 and sowing occurs in the main sowing window.

The phosphorus requirement of wheat can be calculated using 3.5 to 4.0kg of phosphorus per tonne of grain to maintain soil phosphorus level. Replacement phosphorus rates can be adjusted to 'run down' or 'mine' the soil phosphorus bank to a desired level.

The knife point, press wheel, inter-row system allows for sowing to occur earlier, which results in more efficient

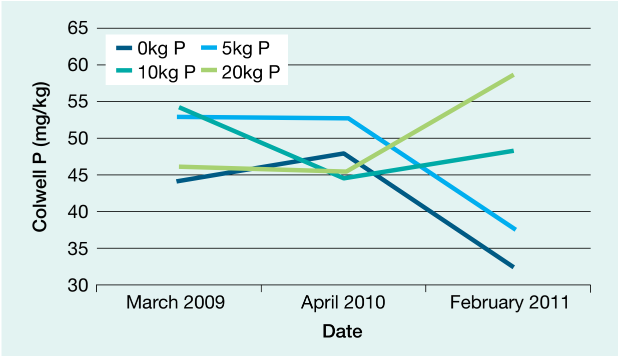


FIGURE 1 Change in soil Colwell P over time with various phosphorus treatments

phosphorus use. Even though phosphorus demand has increased, the more efficient use allows for existing critical soil test values to remain as a reliable indicator of applied phosphorus response.

Late sowing and/or physical (hard pan) or chemical (acidity) impediments to phosphorus uptake will require higher critical Colwell P levels.

Significant cost and risk reduction is possible when soil phosphorus levels are high through the manipulation of applied phosphorus rates.

ACKNOWLEDGEMENTS

The Grains Research and Development Corporation (GRDC), Lockhart and District Ag Bureau, EH Graham Centre for Agricultural Innovation, Precision Agriculture Bendigo, Agritech NSW and farmer co-operators Brent Alexander, Geoff Bergmeier, Mark Bender, Mark Day, Steven Dore and Bill Pincott.

CONTACT

Mark Harris
E: mharris@rmsag.com.au

Long-term nitrogen and phosphorus use — the implications

Bruce Ramsey
Agritech Crop Research

Aim

To describe the cumulative effect of five different rates of nitrogen (N) fertiliser and five different rates of phosphorus (P) fertiliser on grain yield and protein content (%) in a cropping rotation.

Method

A long-term field trial was established at Rand, New South Wales during 2008 to evaluate the crop response throughout the rotation to rates of applied phosphorus in combination with a range of nitrogen rates.

The site was sown to wheat during 2008, canola during 2009 and wheat again during 2010 — the same rates of phosphorus and nitrogen have been applied in each of the three years of the cropping rotation.

Five rates of phosphorus (0kg/ha, 10kg/ha, 20kg/ha, 30kg/ha and 40kg/ha) and five rates of nitrogen (0kg/ha, 15kg/ha, 30kg/ha, 45kg/ha and 60kg/ha) were applied annually using triple superphosphate and urea.

All phosphorus rates were applied at sowing directly with the seed, while the initial nitrogen rates were banded 2.5cm to the side and 4–5cm below the seed at sowing using a Janke twin banding and knife point.

Depending on seasonal conditions, additional topdressing of nitrogen was applied at the five-leaf (GS15) to first-node (GS31) growth stages in order to reach the seasonal potential yield, based on stored soil moisture, growing season rainfall (GSR) to date and projected GSR.

Efficacy was measured by assessing; crop dry matter (DM) and complete plant tissue analysis (whole tops) at GS15, grain yield, quality (protein, hectalitre weight, and screenings) and complete grain tissue analysis.

Complete topsoil samples were taken each year from a select number of treatments to track changes in soil parameters through the term of the trial.

Annual rainfall during 2010 was above average (752mm vs 509mm) compared with the long-term average. GSR was also 68mm above average (393mm vs 325mm) — this was mainly due to an extremely wet October (136mm), which saw the plots flooded during mid October. Fortunately the flood waters rose and dropped reasonably quickly avoiding any significant crop damage.

Grain protein levels and water use efficiency (WUE) indicated that yields were not restricted by a lack of nutrients, 11.9–13.6% protein and 13.04–18.99kg/mm available moisture WUE). The floods during mid October may have resulted in some denitrification at this site.

During 2008, the site had an average Colwell P level of 67mg/kg, which was an average of four soil samples (one per replicate: 61mg/kg, 68mg/kg, 60mg/kg and 78mg/kg). Samples taken before sowing during 2009 showed no difference between treatments and ranged between 68.3mg/kg and 85mg/kg (see Figure 1).

Conclusions

On this high-soil-phosphorus site (67mg/kg Colwell P 2008) it has taken just two years to show significant changes in soil phosphorus levels.

Where no phosphorus was applied, levels decreased to 81% of their initial starting point (54.5mg/kg vs 67mg/kg Colwell P). Applying 10kg/ha of phosphorus during 2008 (a very dry year) and 2009 (dry finish to the season) maintained soil phosphorus levels, while applying 30kg/ha and 40kg/ha of phosphorus increased soil phosphorus levels, although there was no difference between the soil phosphorus of these treatments at the start of the 2010 season.

Above-average yields during 2010 resulted in significant amounts of phosphorus being removed from the soil and this will impact on the levels of soil phosphorus available to the crop during 2011. It is likely the range in soil phosphorus levels will increase going into 2011 as a result of mining and build up of soil phosphorus levels according to the rates applied.

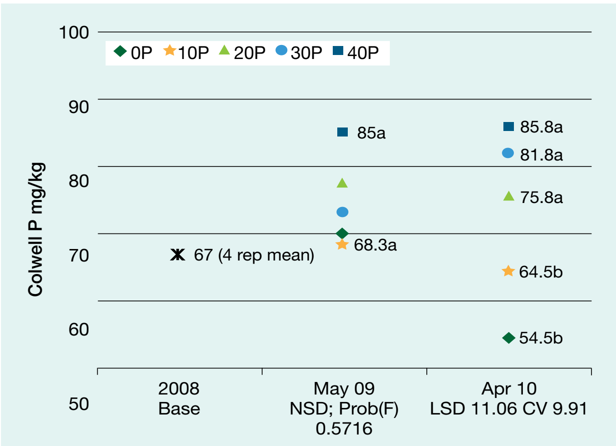


FIGURE 1 Soil phosphorus levels at Rand, NSW 2008–2010

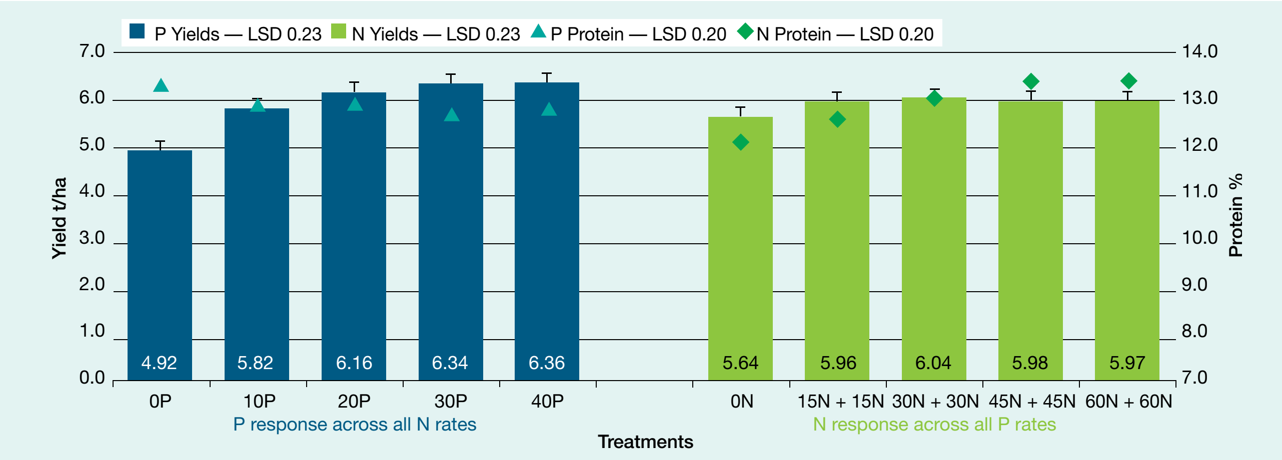


FIGURE 2 Grain yield and protein (%) of nitrogen and phosphorus treatments, 2010

Based on the factorial analysis, crop DM production, plant tissue phosphorus levels and phosphorus uptake all increased as rates of phosphorus applied increased up to 30kg/ha.

As shown in Figure 2 grain yields increased from 4.92t/ha as phosphorus rates increased up to 20kg/ha (5.82t/ha and 6.16t/ha). No further increase in yield was achieved by applying rates of 30kg/ha and 40kg/ha of phosphorus.

An increase in yield associated with the application of at least 10kg/ha or more of phosphorus, resulted in a dilution of grain nitrogen and hence decreased protein levels across all nitrogen treatments (see Figure 2).

Grain protein levels did not decrease further as phosphorus rates increased above 10kg/ha.

Grain phosphorus concentration increased when 30kg/ha was applied compared with nil phosphorus (0.258% cf 0.269%). When this was multiplied by the actual yield achieved, phosphorus removal in the grain was calculated to be 12.69kg/ha at the nil phosphorus and 17.0kg/ha at the 30kg/ha of phosphorus rate.

Grain protein levels increased as rates of nitrogen increased up to 90kg/ha (split applications) — no further increase in protein level was achieved by applying 120kg/ha of nitrogen (see Figure 2).

ACKNOWLEDGEMENTS

Thanks to Angus Macneil *Green Park Pastoral* for participating in these long-term trials, which were funded by Incitec Pivot, with data analysis carried out by Agritech. A full trial report, with 2011 soil test results, is available by contacting Jason Collier, Rand Ag and Fertilzer..

CONTACT

Jason Collier
Rand Ag and Fertilizer
M:0428 295 206
E: jacko@hehirstransport.com.au

Trace element nutrition — a crucial balance

An excerpt from Evan Ryan's Nuffield Scholarship final report

Evan Ryan
Clontarf, Yarrawonga

Key points

- Trace elements play a pivotal role in human and crop health — yet many growers overlook them in favour of macro-elements, such as nitrogen phosphorus and potassium.
- A greater understanding and focus on trace elements in crop production can boost yields and end product nutritive values.
- Benchmark broadacre crops based upon the best performing areas of paddocks and their corresponding soil and tissue trace element values.
- Understand what a 'critical value' is and use its definition to manage yield in response to trace element applications at economically sensible levels.

Generally speaking, Australian growers focus on macro elements, such as nitrogen (N), phosphorus (P) and potassium (K) in their crops at the expense of trace elements such as iron (Fe) and zinc (Zn). As a result, these key elements for crop growth are often overlooked, to the detriment of plant growth and ultimately human health.

In contrast, crops with a sufficient supply of trace elements grow efficiently and return yields and profits to the grower's pocket.

A Nuffield scholarship study has confirmed my belief that we can further optimise plant production with the use of innovative methods to manage trace elements. My scholarship has allowed me to expand my knowledge in the area of trace element nutrition and through this I hope to improve the productivity and profitability of Australian grain farms.

On our farm in south-eastern Australia, our family has adapted our broadacre cropping equipment to inject liquid trace elements to the seed row during sowing. Initial observations of the improvements in crop growth and yields both on our farm and in other regions of Australia have been encouraging, inspiring us with enthusiasm to learn more.

In paying closer attention to trace elements, growers will gain a better understanding of the role they play in crop production and growth. And by providing adequate essential mineral concentrations in optimum amounts to staple foods, growers will also be able to offer more value to consumers, resulting in healthier communities.

The human condition

Trace elements, such iron and zinc, are required in extremely small quantities (less than 100 parts per million in plant dry weight), yet are essential for the correct functioning of many plant and animal (including human) biological systems.

Micro-nutrient malnutrition is a growing concern in the developing and developed world — it results in mental retardation, immune system impairments and overall poor health.

Half of the world's population is deficient in iron and zinc, which can be attributed to many factors including personal wealth, staple foods consumed, the source of the food products and the nutritional content of the soil from which plant and animal produce is grown.

Zinc deficiency is prevalent where cereal-based foods are the main source of kilojoule and protein intake in the diet and is often exacerbated by the concentration of zinc in cereal crops being inherently low. The situation is often made worse by cereal crops being grown in zinc-deficient soils. For example 50% of India's soils are zinc deficient, but agronomic biofortification (enrichment) of rice through plant breeding efforts may save the lives of 48,000 children in India each year.

Zinc and cadmium (Cd) are chemically very similar, competing for binding sites and transport proteins. This means plants will take up cadmium and deposit it in the grain where zinc is not available. The high content of cadmium in Asian grain is of a growing concern as it is toxic to humans in very low concentrations.

Sliding scale

Trace element content of grains has unintentionally been decreasing since the 'green revolution' during the 1960s, since semi-dwarf cereal varieties were introduced.

This could be linked to the fact that trace element re-distribution at grainfill (with photosynthates) from the leaves and stem to grain does not catch up with the much-enhanced re-distribution of photosynthates in these semi-dwarf, short-straw cereals.

There is currently a worldwide program, *Harvest Plus*, which aims to breed crop cultivars with elevated grain trace element levels.

However, like most complex problems the solution must come from an integrated multidisciplinary approach. High-yielding varieties that require more nutrition to develop to their genetic potential are of little advantage if they are planted on trace-element deficient soils.

Adding value

The addition of trace elements in some cropping situations will both increase on-farm profitability, and end-product quality, and possibly the value of the product being produced.

This is because the soil may be deficient in trace elements due to the parent material from which it was derived, which in turn means the produce grown is deficient in important elements causing a mineral deficiency in those consuming the produce.

The first 60 days are crucial to plant growth and these early days of crop growth can determine the final yield so it is important to minimise stress when plants are sensing their environment and placing energy into root exploration and shoot growth.

The challenge is that most soils are deficient in nutrients due to poor past management practices of the parent soil material from which they originated. Growers need to manage this according to needs based on the type of plants and the soil in which they are growing.

Supplying trace elements to plants optimises plant growth when required and their role in assisting plants to survive and thrive through stressful growth periods is widely documented.

Trace elements also are vital in mediating the production of plant hormones such as cytokinins, auxins and gibberelic acids as components of enzymes — these hormones are important for mediating growth and plant stress responses (see Figure 1).

By providing an optimum environment for plant growth in the soil with trace elements the crop is set up to thrive under ideal conditions and survive stress.

How much is enough?

The established practice in production agriculture is that trace element fertilisers should be applied to reach a critical value and then no further production gain is to be made to fertilise beyond this point.

The variability inherent in sampling plant materials for analysis and the variability between plants within a field means a critical value used for guidance without knowledge of variability within plant samples will give a false impression of the plant's nutritional needs.

The YARA/PHOSYN company has taken the innovative step of benchmarking leaf tissue samples they have analysed and graphed, showing the 'low', 'normal' and 'high' values for plant growth using the program MEGALAB. This analysis of information for a given region, crop type and trace element is powerful data enabling growers to benchmark their crops' performance (see Figure 2).

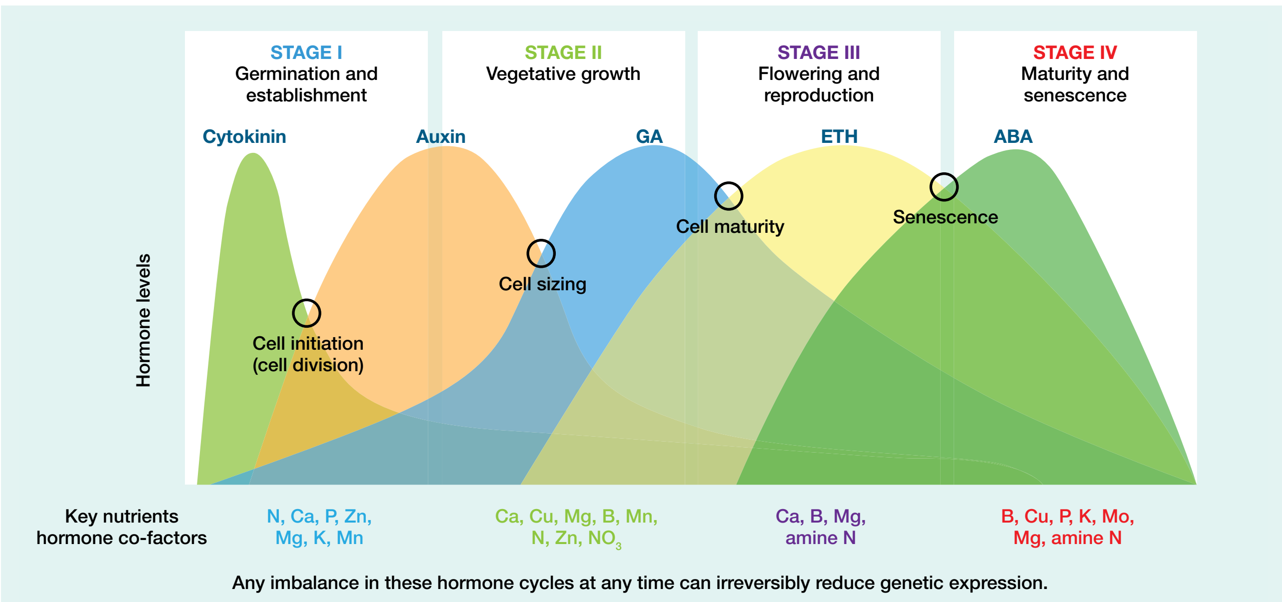


FIGURE 1 Plant hormone cycles

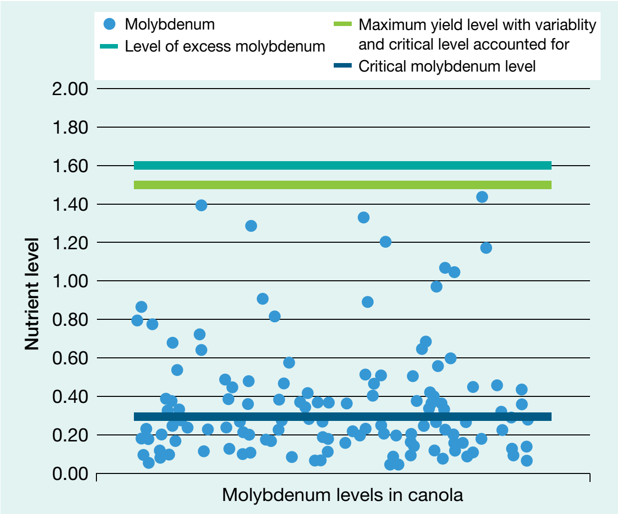


FIGURE 2 Molybdenum in canola plant tissue samples in Victoria and the upper and lower limits associated with the tests (source Hancl, 2009)

Currently most tissue tests only identify whether the sample submitted has adequate levels or not. This information alone is not adequate to allow growers to optimise the crop's growth through input management.

Growers and their advisers need to know where the sample sits within a benchmark of crops within the region, crop type and for the specific element. Armed with nutritional benchmarking information they can decide how far to push the production system's inputs, given the profitability of specific inputs in question.

Fertiliser applied is a good investment as long as the soil can provide nutrition to the plant when required.

Foliar applications of fertiliser have a place where soils are hostile or strongly absorb a given nutrient. This can often occur with trace elements applied to soils, particularly if there is a macro-element bound to it. Common interactions include selenium (Se) and sulfur (S), and zinc and phosphorus.

A general philosophy in terms of ameliorating a plant nutritional deficiency is to "keep a steady hand on the tiller", in other words it is not advisable to make rash changes in the fertiliser program until the correct reason why the plant is deficient is determined.

Generally, advisers and growers take a measured and logical approach until a comprehensive view of the nutrient interactions can be gauged.

Be mindful of the interactions between elements when deciding how much to apply to correct a deficiency. This balance between nutrients in the soil and the plant demonstrate the effects that elements have on trace element nutrient availability.

Most nutrients interfere with the availability or uptake of another (antagonism).

In Figure 3, the green lines indicate an antagonistic relationship between each connecting element.

On the other hand, some elements can stimulate the uptake or increase the availability of another. These lines are indicated by the blue lines in Figure 3.

Examples of the antagonistic and synergistic effects between nutrients include:

- Excessive, phosphorus applications will reduce the availability of iron, calcium, potassium, copper and zinc, which increase sterile florets, ergot, lodging and disease.
- High levels of calcium will reduce the availability of phosphorus, zinc, magnesium, iron, potassium and manganese. This reduces seedling vigour, tillering, standability and maturity.
- Excessive nitrogen fertility can reduce the availability of boron, potash and copper. This increases sterility, ergot, flowering, increasing lodging and transpiration.
- Increased levels of boron will increase the availability of nitrogen. This increases chlorophyll, protein and amino acid production.

Crop types and species also have varying responses to trace element application based on their genetics.

Table 1 highlights the differences to consider when testing for and treating a deficiency.

Growers need to assess crop production in each paddock, separately to other local growers, and determine critical levels for trace element deficiency for their system. Growers may think their nutrient levels are adequate based on published critical levels of leaf tissue analysis or soil

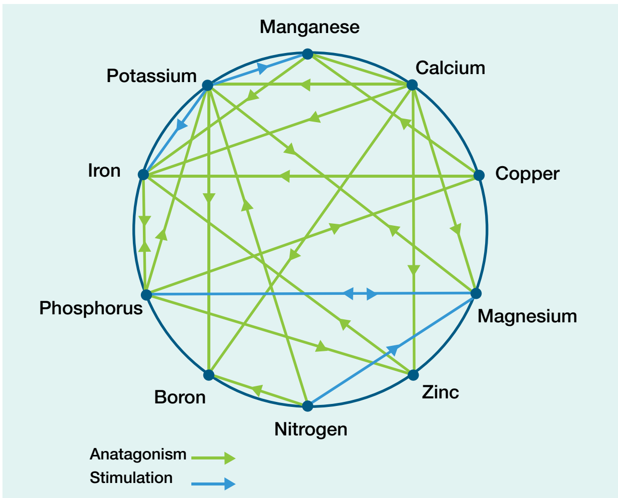


FIGURE 3 Mulder's chart of nutrient interactions (Larocque, 2010)

TABLE 1 Genetic response of crops to trace element fertilisers

Crop	Zinc	Copper	Boron	Manganese	Iron
Barley	Medium	Medium	Low	Medium	High/medium
Canola	Medium	Low	High	Medium	_
Oats	Low	High	Low	High	Medium
Wheat	Medium/low	High	Low	High	Low

(Alloway BJ, Zinc in Soils and Crop Nutrition, 2008)

testing. However, the critical level for each farm needs to be determined to afford the greatest profitability.

Each field, crop type and variety has a slightly varying requirement for nutrition. No biological system is identical — to achieve an average optimum an overview of the system is required.

FOR MORE INFORMATION

Evan's full scholarship report can be found at www.nuffieldinternational.org/rep_pdf/1283473559Evan_Ryan_Final_(2).pdf

More information on Harvest Plus is available at www.harvestplus.org.

ACKNOWLEDGEMENTS

Nuffield Australia and the Grain Growers Association (GGA) made my travel and study possible for this project. The assistance provided by these two organisations to this study, to the development of leadership, knowledge transfer and guidance in both Australian and worldwide agriculture has been both visionary and practical.

Treating hostile subsoils

Peter Sale [1], Jaikirat Gill [1], Renick Peries [2] and Caixian Tang [1]

[1] Department of Agricultural Sciences, La Trobe University

[2] DPI Victoria, Geelong

Key points

- Subsoil manuring involves adding 15–20t/ha of organic amendments in rip lines into the top layer of clay subsoils to increase crop water use and yields.
- The practice is expensive — but the benefits are substantial and appear to be long-lasting.
- Further research is underway to lower the costs, by trialling cheaper on-farm materials, perhaps in combination with organic waste products.
- Interested growers are trialling the practice on farm.

Large areas of land in south-west and south-east Australia have dense clay subsoils. These are the so-called duplex soils, where lighter-textured sandy-loam or loam topsoils, overlie dense clay. The problem with many of these subsoils is that the fine clay particles are packed so tightly together there is little pore space for air to move to the respiring roots, or for water to infiltrate into the subsoil.

These soils are often sodic, or high in sodium (Na), and so any existing pore spaces are blocked by dispersive clay particles.

The subsoils are considered to be 'hostile' to plant roots — the roots are generally unable to grow readily into the layers because the dense clay is too hard when dry, or too anaerobic (lacking oxygen) when wet.

In many drier areas, the clay subsoils are sometimes saline and can contain toxic levels of boron, but these constraints are not generally present in the high-rainfall zone (HRZ).

Plant roots are restricted for the most part, to the topsoil layers. The so-called 'bucket size' of the soil (the soil volume providing water and nutrients to plant roots) is small and limited. High-yielding crops just do not 'finish' in dry springs, because they run out of water, as their roots cannot grow into the clay.

Grain growers in the HRZ asked whether anything could be done to address this problem. However, the prevailing attitude was that it was just too costly to ameliorate these hostile subsoils, and growers just had to live with them.

Tackling the problem

During 2004 researchers worked with operators of a mixed farming business at Yaloak Estate at Ballan, in the HRZ of south-west Victoria. We accessed funding from the Australian Research Council (ARC) to undertake research on how to manage these subsoils. Two adjacent field experiments were established on the farm.

Four treatments were employed:

(i) Burying high rates of organic material at depth in the subsoil.

(ii) Deep ripping and incorporating high rates of gypsum.

(iii) Incorporating nitrogen (N) and phosphorus (P) fertiliser at depth.

(iv) Comparing the effects on paddocks with and without a history of four years of grazing lucerne. This approach hypothesised that lucerne's deep tap roots would create plenty of air space in the subsoil.

The treatments were set up during April 2005, and the sites were managed along with the rest of the paddock, which was cropped to a red wheat during 2005 and 2006, and to canola during 2007.

The results, where high rates (20t/ha) of organic material were incorporated at 30–40cm deep in twin rip lines 80cm apart, on raised beds, were particularly effective. This approach has now led to the development of a new practice termed 'subsoil manuring'.

Results to date

Grain yields were determined for the control plot and lucerne pellet treatments, at the non-lucerne site, for three successive crops following subsoil manuring during 2005 (see Table 1).



TABLE 1 Successive crop yields at the non-lucerne site at Ballan (2005–2007), following subsoil manuring during May 2005

Treatment	2005 yield red wheat (t/ha)	2006 yield red wheat (t/ha)	2007 yield canola (t/ha)
Control (commercial crop)	7.6	3.6	1.6
Subsoil manured (20t/ha lucerne pellets)	12.9	5.6	2.5
LSD (P = 0.05)	1.8	1.6	0.8
(% change)	(70%)	(55%)	(56%)

The other treatments included deep ripping, deep MAP fertiliser, deep coarse sand, and deep gypsum. They resulted in yields in-between those for the control and the subsoil-manured treatments (lucerne pellets, Dynamic Lifter® pellets, or the lucerne pellets/MAP/gypsum combination). The yield responses at the lucerne site were consistently lower than at the non-lucerne site.

The yield responses of the three crops to subsoil manuring during 2005 ranged between 50–70% of the control treatments (see Table 1). The crops on the control plots were relatively low in nitrogen as the seasonal conditions each year were not generally favorable during vegetative growth, so minimal in-crop nitrogen was used across the three years, apart from starter applications of MAP at 70kg/ha/year.

In contrast, the subsoil-manured treatments received large nitrogen inputs from the organic amendments, which contained around 3% nitrogen. However, the extra 5t/ha of high-protein wheat (13.4% protein, compared with 9.1% for the control) was a surprise during 2005 when late rain during November 2005 contributed to an average growing season rainfall (May–November) of 376mm.

In the following drought year (2006) the sites received only 178mm of GSR, but still the subsoil-manured plots yielded an extra 2t/ha (see Table 1).

Conditions during 2007 were poor for canola because of the late, cold start to the season which was then followed by a dry spring until rain fell during late October. Nevertheless, the subsoil-manured plots produced close to an extra tonne per hectare of canola yield, compared with the control plots.

During 2007 an additional experiment found poultry litter from broiler sheds was equal in effectiveness to lucerne pellets. Poultry litter was more readily available and considerably less expensive. However, the study showed 15t/ha of poultry litter produced higher yields than 10t/ha of poultry litter, and 10t/ha produced more grain than 5t/ha of poultry litter. A rate of 20t/ha of poultry litter is being used as the standard subsoil manure application rate. Interestingly, back-of-the-envelope calculations, based on estimated subsoil manuring costs with poultry litter during 2005, and grain prices across the three subsequent years, suggest that it would have paid for the 2005 intervention each year, from 2005 to 2007. Unfortunately, the price for the poultry litter has now increased sharply since 2005.

During 2009 subsoil manuring was evaluated at other sites across south-west Victoria with funding from the Grains Research and Development Corporation (GRDC). The 2009 season had been shaping up as a bumper year for grain growers in the Western Districts. However, an extended heat wave, with temperatures exceeding 35ºC for more than 10 days in early November, negatively impacted on crop yields.

The subsoil was starting to dry out during late October before the heat wave, except for the subsoil-manured plots, which had wetter subsoils, and which appeared less affected.

Final crop yields for the 20t/ha poultry litter and the control treatments at the three sites during 2009 are presented in Table 2. This data shows that the large increases in grain yield with subsoil manuring that had occurred at Ballan from 2005–2007, were repeated at the other sites in south-west Victoria during 2009.

TABLE 2 Crop yields at different sites in south-west Victoria during 2009, with and without subsoil manuring

Treatment	Barley (Gairdner) at Winchelsea (t/ha)	Wheat (Derrimut) at Derrinallum (t/ha)	Wheat (Sentinel) at Penshurst (t/ha)
Control (commercial crop)	4.4	5.0	4.8
Subsoil manured (20t/ha poultry litter)	7.7	9.8	7.6
LSD (P = 0.05)	1.3	1.3	0.8
(% change)	(75%)	(96%)	(58%)

Long-lasting impact

A key question raised was "how long will the effects of subsoil manuring last?".

Does subsoil manuring need to be repeated every few years, or might it last for many years?

On returning to the paddock at Ballan during September 2009, four years and four months after 20t/ha of lucerne pellets had been incorporated at 30–40cm depth, the clay layer at this depth in the control plots was dense and hard. In contrast, the 30–40cm clay layer in the subsoil-manured plots was soft and friable and was made up of small aggregates (see Figure 1).

The clay layer that had received the organic amendment had been completely transformed and looked like topsoil, four years after the subsoil intervention.

Reasons for the yield increases

Subsoil manuring significantly increased crop water use, boosting crop yield potential. During 2005, the crop was able to use 60mm of additional soil water from the 40–80cm subsoil layer in the subsoil-manured plots compared with the control plots.

Concern that the 2005 crop had used all of its deep subsoil water, and there would be no subsoil water below 40cm for the 2006 crop, was unfounded. The whole soil profile was refilled with soil water from summer and autumn rain during 2006. In fact, the subsoil-manured plots (averaged over the lucerne and lucerne/MAP/gypsum treatments) at the non-lucerne site, captured an extra 72mm of rainfall during the summer fallow of 2006, and a further 26mm of rainfall in-crop at tillering in 2006, compared with the control treatment.

This extra 98mm of available water contributed to the extra 2t/ha of grain in the 2006 drought year. As much of the extra soil water was stored below the depth of 40cm, subsoil manuring on these cropping soils with physically-constrained subsoils, appeared to lead to 'water-harvesting in the subsoil'.

These research findings, and results from other studies, suggest that the incorporation of the organic amendment in the clay subsoil increases microbial growth in the amended soil, as the soil microbes are provided with the organic substrate.

This activity produces microbial exudates that enable clay particles to form into small aggregates. This appears to provide pore space that contains plant-available air and water.

These resources enable the roots to proliferate in the subsoil, using the plant nutrients being released from the organic amendment.

Recent glasshouse experiments at La Trobe University (LTU) have shown how roots preferentially grow in the amended organic matter layer in the clay subsoil. The results from this field trial highlight the role of the roots in improving physical properties in the subsoil.

It is likely that proliferating roots release more root exudates (sugars and amino acids) that further feed the soil microbes. Exudates from the microbes continue to increase the aggregation of the clay particles away from the litter layer, improving aeration and softening the soil, enabling more roots to proliferate.

(a) (b)

FIGURE 1 The appearance of the 30–40cm subsoil clay layer, four years after lucerne pellets had been incorporated in the layer (a), compared with the clay layer in the control soil (b)

The results in Figure 1 suggest that as long as there is active, continuing root growth in the amended clay layers, as would occur with continuous cropping, then the effect of subsoil manuring will be long-lasting.

Improving the cost-effectiveness

Cost is a significant barrier to the widespread use of subsoil manuring. With the current price of poultry litter at about $10 per cubic metre, and with 2.5m^3 to the tonne, then the cost of air-dried litter is about $25/t.

If freight was $5/m^3, then the price increases to $37.50/t. Then there is the incorporation cost and material handling costs on farm.

There are several approaches under investigation to try and reduce the costs of subsoil manuring. One approach is to use existing on-farm materials, such as crop stubble, in order to avoid freight costs. Preliminary results with wheat straw have been mixed.

There may be a role for specially-grown green-chop crops, which might need to be blended with stubbles and manures.

A second approach is to target those parts of the paddock or farm with the most difficult and hostile subsoils, where the investment in subsoil manuring will give the greatest return. A goal here would be to map the severity of the subsoil constraints across the paddock.

Another approach would be to better define the upper end of the response curve to added amendments. This could help calculate the amount of amelioration necessary to yield a lasting beneficial response, while minimising the outlay.

Subsoil manuring — the future

While more research is needed to improve the cost effectiveness of the technology, interested growers have the opportunity to evaluate the practice on their farms.

Growers can contact Dr Renick Peries from the DPI Victoria, Geelong, who has been working with subsoil manuring for many years and has developed the design for the Peries-Wightman subsoiler — an impressive twin-ripper machine that will incorporate high rates of organic matter into the clay layer of these duplex soils. The machine can be transported onsite and hired to do areas large enough to record yields with a yield-monitor-equipped header.

Alternatively, for a smaller test area, growers can attach a large pipe to the back of a strong ripper and manually apply calculated quantities of amendment using a bucket and funnel, after allowing for tractor speed and distance between the rip lines.

Photo: Ben White

Research is also required to determine whether this technology is limited only to the HRZ, where there is more rainfall to capture and yield potentials are higher than in drier areas. Intuitively, this makes sense — on the other hand, the benefits of improved fallow efficiency with problem paddocks that cannot capture water may be significant, even in lower-rainfall areas. Hopefully, there will be opportunities to trial the technology in these areas, and perhaps in areas where the clay subsoils are saline.

There is no substitute for knowing the real cropping potential of a problem paddock (with dense clay subsoil) — this requires effort. Nevertheless, it would be valuable to determine what is achievable by modifying the soil profile to maximise the 'bucket size' and capture, store and then use every drop of available rain that falls on the paddock.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the involvement and support of Peter Yunghanns and John Sheahan at Yaloak Estate, and David Watson from AgVise Pty. Ltd. for their support at different stages of the research at Ballan. We are also indebted to Rentiers Machinery Pty. Ltd. at Derrinallum, the Wilson family at Winchelsea, and the Herrmann family at Penshurst for their support for the field experiments on their farms. The support of the Australian Research Council for funds for the Linkage Project LP405551, and the GRDC for funding is acknowledged.

CONTACT

Peter Sale
P: (03) 9479 2188
E: p.sale@latrobe.edu.au

Renick Peries
P: (03) 9479 2188
E: Renick.Peries@dpi.vic.gov.au



Microwave treatment for the control of fleabane and prickly paddy melon

Graham Brodie, Carmel Ryan and Carmel Lancaster
The University of Melbourne

Location: Dookie Campus, University of Melbourne

Plot size: Individual pots

Replicates: 10 plants per treatment

Key points

- Fleabane (*Conyza* spp.) and prickly paddy melon (*Cucumis myriocarpus*) have become difficult-to-control weeds in minimum tillage systems.
- Fleabane resistance to glyphosate and other chemicals has been reported in the western Darling Downs, Queensland.
- Interest in the effects of high frequency electromagnetic waves on biological materials dates back to the late 19th century, while interest in the effect of high frequency waves on plant material started during the 1920s.
- Microwave energy kills fleabane and paddy melon plants at all stages of maturity.
- Consider microwave treatment as part of an integrated weed management plan rather than the sole management strategy.

Aim

To determine the effect of microwave radiation on fleabane and paddy melon plants

Method

A prototype system, energised by the magnetron of a microwave oven operating at 2.45GHz, used an 86mm by 43mm rectangular wave-guide to channel the microwave energy from the oven's magnetron to a horn antenna outside of the oven. This allowed the oven's timing circuitry to control the activity of the magnetron.

Horn antennae have been used for weed control experiments during the past.

The prototype system, which is based on a modified microwave oven, used a horn antenna to apply microwave energy to weeds

The microwave power of the prototype system was determined using two samples of water. One acted as a control to determine the energy balance of the ambient air, while the other was heated by the microwave system.

The prototype system produced an average output power of 541.3 Watts.

The prototype system was used in a three-factor experiment where 120 individually potted fleabane plants and 120 individually potted paddy melon plants were exposed to microwave radiation using two different applicator antennae (designated as antenna 1 or 2 in these experiments) for six different exposure times (0, 5, 10, 15, 30 and 60 seconds).

Each treatment set consisted of 10 individual plants. The plants used in this experiment varied in maturity. Some were at flowering or fruiting stage, in the case of paddy melon, while others were still in their vegetative growth stage.

Plants were allowed to acclimatise to their pots before treatment and were randomly allocated to different treatment groups. Plants were watered regularly after treatment to maintain optimal growing conditions.

Prototype microwave antennae used in the experiment (antenna 1 is on the left and antenna 2 is on the right)

Results

Results are shown in Table 1. The first antenna design provided 100% plant mortality between 15 and 30 seconds of microwave treatment. The second antenna design, which delivered the microwave energy in a more concentrated dose, provided 100% plant mortality between 2 and 10 seconds of microwave treatment, depending on the species being treated.

Observations and comments

Fleabane and paddy melon are susceptible to microwave treatment. The second antenna design applies a lethal dose of microwave radiation in a much shorter time than the first antenna.

Paddy melon was slightly more susceptible to microwave treatment using antenna 2 than fleabane.

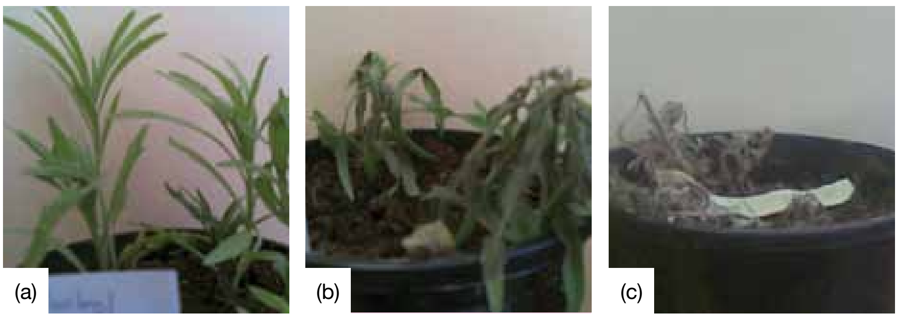
Microwave treatment will not be as cheap as chemical treatments — however its mechanism for killing weeds is different to chemical treatments and this can deal with herbicide-resistant weeds.

Research has already shown that microwave treatment can also kill weed seeds in the upper layers of the soil, allowing longer periods between treatments before weeds become a potential problem again.

TABLE 1 Mean survival percentages for fleabane and paddy melon during microwave treatment experiments

Species	Antenna design	Treatment time (s)					
		0	5	10	15	30	60
Fleabane	Antenna 1	100 [a]	100 [a]	100 [a]	60 [b]	0 [c]	0 [c]
	Antenna 2	100 [a]	50 [b]	0 [c]	0 [c]	0 [c]	0 [c]
Paddy melon	Antenna 1	100 [a]	100 [a]	100 [a]	60 [b]	0 [c]	0 [c]
	Antenna 2	100 [a]	0 [c]	0 [c]	0 [c]	0 [c]	0 [c]
LSD ($P < 0.05$)							16

(Treatments with different superscripts are significantly different to one another)



(a) (b) (c)

Comparison of (a) control fleabane plants three weeks after treatment with (b) plants immediately following five seconds of microwave treatment using antenna 2 and (c) the same five-second treated plants three weeks after treatment.

(a)

(b)

Paddy melon plants (a) immediately after microwave treatment and (b) three weeks after treatment.

SPONSORS

Grains Research and Development Corporation (GRDC).

CONTACT

Graham Brodie

T: (03) 5833 9273

E: grahamb@unimelb.edu.au



Control of insect and mite pests in grains — insecticide resistance and integrated pest management (IPM)

Paul Umina [1], Svetlana Micic [2] and Laura Fagan [3]
[1] CESAR and The University of Melbourne
[2] Department of Agriculture and Food, WA
[3] University of Western Australia

Key points

- Growers may face significant challenges in the future due to insecticide resistance in redlegged earth mites and other crop pests.
- More strategic and integrated approaches to insect pest management are needed.
- Insecticide sprays are effective at controlling crop pests, but do not always provide yield benefits.

Background and aims

Pest species within the grains industry pose a serious threat as farming practices change. To avoid costs associated with crop failure and increases in pesticide usage, potential pest species must be identified and their basic biology determined so effective control strategies can be devised. During the past decade, a large amount of research has been carried out on a number of important pests, such as blue oat mites (BOM) and the redlegged earth mite (RLEM). This has led to important breakthroughs in the way we now control these mites.

Underpinning an integrated pest management (IPM) approach is correct identification and monitoring of both pest and beneficial insects. Misidentification of pests can cost growers money through ineffective control strategies and pesticide applications. Monitoring of pest and beneficial numbers is also critical for making informed control decisions.

Earth mites and insecticide resistance

RLEM is a major invertebrate pest, particularly to establishing crops and pastures. Mite feeding significantly reduces seedling survival and development and will often lead to entire paddocks needing to be re-sown. For decades, RLEM have been controlled relatively effectively with broad-spectrum pesticides. However, during 2006 chemical resistance was discovered in RLEM populations in Western Australia. Extremely high levels of resistance to several synthetic pyrethroids (> 200,000 fold in the case of bifenthrin) were detected using laboratory bioassays, and this has translated to significant yield losses in the field.

This resistance has been shown to have a genetic basis, persisting among mite populations after several generations of culturing away from the paddock. This means it can be passed on to offspring and will persist in the field indefinitely. Further surveys of RLEM have found this resistance to be more widespread than first thought. We have carried out field surveys since 2007 in order to map the spread and distribution of insecticide resistance in WA and other states. Resistance was tested from 115 paddocks across 85 properties in WA between 2007–2010. Twenty-eight individual paddocks were found to contain mites with resistance to the synthetic pyrethroid bifenthrin. These paddocks are spread across 19 separate properties. Although resistance ratios were not determined in each case, the percentage survival at the discriminating doses examined indicates the level of resistance for each of these populations is very high. At this stage, resistance has not been detected outside of WA.

In total, resistance has now been demonstrated for five synthetic pyrethroids, all of which are currently registered to control RLEM in Australia. This means growers should not alternate between the different synthetic pyrethroids when faced with resistant RLEM. Careful consideration of chemical rotations between different chemical classes is critical. It is encouraging that resistance to organophosphate chemicals has not been detected, although there is evidence of genetic tolerance in some populations of RLEM.

Concerns surrounding other crop establishment pests and chemical use also exist. High levels of tolerance to several organophosphates and/or synthetic pyrethroids have been found in BOM, the lucerne flea and in two emerging mite pests, *Balaustium* and *Bryobia* mites. This shows that current pesticide usage is unlikely to be a sustainable practice and also helps explain the increasing number of reports of these species persisting in the field after multiple chemical applications. Smarter chemical use is critical and a more strategic and integrated approach to pest management is needed.

IPM trials

IPM is an accepted approach to sustainably and cost-effectively manage invertebrate pests. IPM coordinates the use of pest biology, environmental information and available technology to prevent unacceptable levels of pest damage by the most economical means, while posing the least possible risk to people and the environment. Although growers have adopted IPM in the cotton industry and for several horticultural commodities, there has been relatively little uptake in broadacre farming systems throughout Australia, which tend to rely heavily on broad-spectrum insecticides for the control of insect pests.

A recently-funded Grains Research and Development Corporation (GRDC) project *Developing and Promoting Integrated Pest Management in Australian Grains* aims to examine alternative approaches to insect pest management in grain crops across Australia.

During winter 2010, five on-farm trials were established to address the uptake of IPM in broadacre farming; two in WA, and one each in South Australia, Victoria and New South Wales. Canola was sown across all trial sites during 2010 and wheat will be assessed during 2011.

At each of the trial locations, a series of 12 plots (each > 50m x 50m in size) were assigned to one of three pest management approaches: (1) No insecticide input (control); (2) strategic (or IPM) approach: insecticides applied only when needed following accurate monitoring of pest and beneficial invertebrates (combined with assessments of plant damage). When insecticides were needed the most selective or 'soft' chemical option was chosen; and (3) conventional: insecticides applied according to typical grower practice in this region.

Invertebrates were assessed using a combination of methods including vacuum sampling, pitfall traps, direct visual searches, sweep netting and extracting invertebrates from soil core samples. In addition, plant numbers, yields and harvest index, and the level of pest-feeding damage to plants were measured at various stages throughout the season.

A number of the invertebrate samples collected are still being sorted or analysed in each state (including WA), so the results discussed here must be considered as preliminary only.

In the Victorian trial, the strategic treatment incorporated an insecticide seed dressing, while the conventional treatments received two separate foliar sprays; a bare-earth of bifenthrin, and a post-emergent application of omethoate. At seven, 14 and 28 days after crop emergence, there was a significant reduction in plant numbers in the control compared with the strategic plots (see Figure 1). There was no significant difference between the conventional and strategic plots. As a result of excellent spring rainfall, canola plants across all plots grew well throughout the latter part of the season, and numbers of typical 'spring pests' (for example, aphids, diamondback moth, native budworm) were quite low across the site.

The control plots (0.43) had higher harvest index values ($P < 0.05$; LSD = 0.03) compared with the other two treatments. This indicates the canola plants in the controls produced more seed per total plant biomass. It is likely that this is due to lower competition due to lower plant densities in the control plots compared with the other treatments as a result of early season pest feeding damage. As a result (and due to issues with rainfall at harvest), there were no significant differences in yield estimates across the three treatments, although the controls did yield the least.

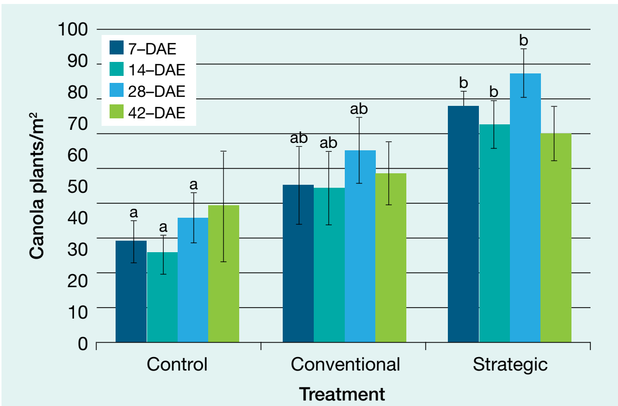


FIGURE 1 Average numbers of canola plants per square metre in plots at the Victorian trial at seven, 14, 28 and 42 days after crop emergence

Error bars indicate standard error of the mean. Different letters above bars indicate significantly different means at each sampling date (at the $P < 0.05$ level, Tukey's-*b* post hoc test)



At the Victorian site, the conventional treatment sprays cost $11/ha and the strategic treatment had a total cost of $1.35/ha, indicating conventional practice may not be the most economical approach for pest management. Preliminary results suggest similar findings at a number of the national trial sites. This indicates routine monitoring, accurate identification of pest and beneficial species and the strategic use of chemicals should be considered by growers and their advisors. During the 2011 trials, the cost of monitoring and time taken to identify invertebrates will be incorporated into our assessments. These components of IPM are likely to be an ongoing challenge in broadacre cropping, particularly for larger farms, and will need to be investigated thoroughly.

CESAR is a science based company that works with government and private organisations to develop and promote sustainable pest control strategies for broadacre cropping systems in Australia.

ACKNOWLEDGEMENTS

Grower Groups and growers involved in both the IPM trials and for allowing collections of RLEM in our resistance work. Stuart McColl and Samantha Strano for direct involvement and Darryl Hardie who is project leader on the IPM project.

CONTACT

Dr Paul Umina
T: (03) 9349 4723
E: pumina@unimelb.edu.au

Long-term rainfall data reveals regular cycles in rainfall patterns at Dookie

Graham Brodie
Melbourne School of Land and Environment,
The University of Melbourne

Key points

- Rainfall records at Dookie Campus started during 1879.
- Smoothing of the rainfall data reveals regular cycles in the rainfall patterns.
- Analysis of these cycles indicates rainfall patterns at the Dookie campus have a long-term upward trend and major cycles with amplitudes of 100mm or more that span 64 years, 17.5 years and 3.5 years.

Aim

To examine the long-term rainfall patterns recorded at the Dookie College weather station.

Method

The weather station at Dookie College is a designated Bureau of Meteorology (BoM) site. Rainfall records at Dookie College started during 1879. With very little interruption, these records show the monthly rainfall patterns between 1879 and the present.

The data was compared with other local records from near by weather stations to confirm its accuracy.

The rainfall data was analysed for long-term trends and patterns using data averaging across a 23-year period.

The 23-year running average was employed by Mazzarella (2007) in his study of several weather-related parameters in the northern hemisphere to remove the effect of sun spot activity on local weather patterns and reveal any underlying weather cycles.

After averaging the rainfall data, Fourier analysis was applied to reveal periodic cycles in the rainfall data.

Fourier analysis involves a mathematical transformation of data to identify the frequency of any cyclical patterns in 'noisy' data sets (Smith 1976). Fourier analysis of this data was carried out using MatLab® software.

Results

The rainfall at Dookie College has maintained a slight upward trend since records started during 1879 (see Figure 1). This trend can be described by a simple linear equation involving the year (designated by the symbol 'y' in the following equation):

$$\text{Rain} = 0.1506\,(y - 1879) + 540.4485$$

However, this simple equation does not describe the rainfall data very well. When the data was analysed using the 23-year running average the cycles became more obvious (see Figure 2).

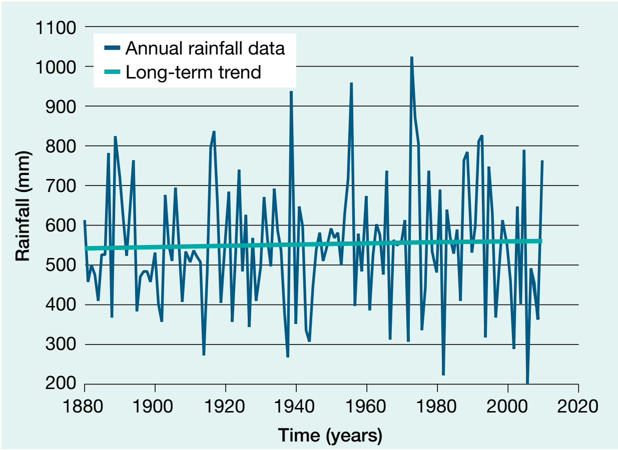


FIGURE 1 Annual rainfall recorded at the Dookie College weather station

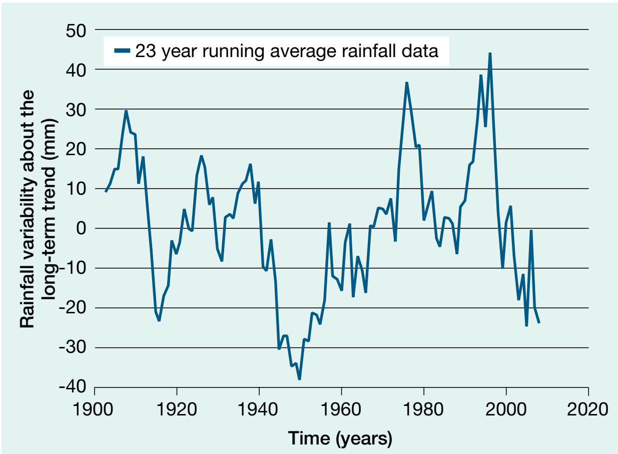


FIGURE 2 Running average of the annual rainfall data from the Dookie College weather station with the long-term trend removed from the data set



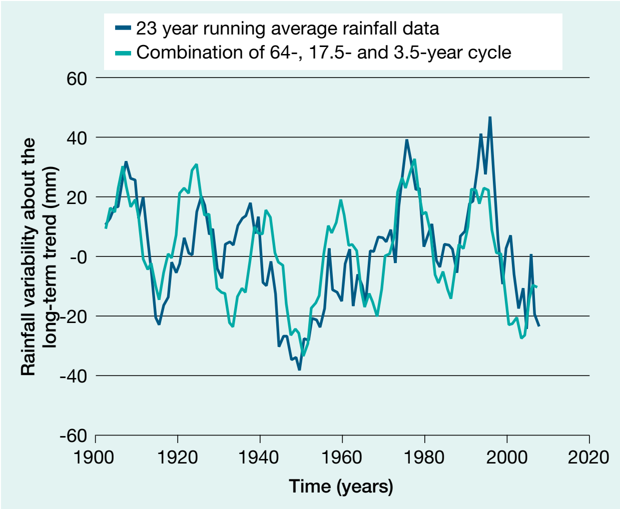


FIGURE 3 Comparison of the running average of the annual rainfall data from the Dookie College weather station with the combined 64-year, 17.5-year and 3.5-year cycles

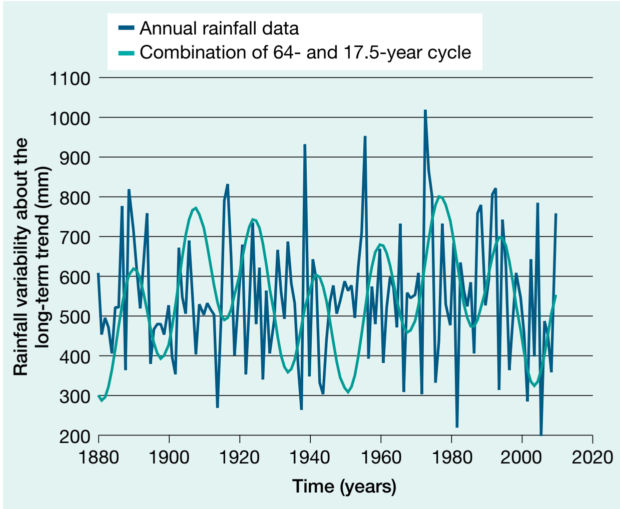


FIGURE 5 Comparison of annual rainfall data from the Dookie College weather station with the 64-year cycle and the combined 64-year and 17.5-year cycles

Fourier analysis revealed a 64-year cycle (frequency = 0.0312), a 17.5-year cycle (frequency = 0.1142) and a 3.5-year cycle (frequency = 0.5634) within the rainfall patterns (see Figure 3).

So the rainfall patterns can be approximated by the following equation:

$$\text{Rain} = 100 \times \text{Sin}(0.0312\pi (y - 18)) + 150 \times \text{Sin}(0.1142\pi (y - 23)) + 120 \times \text{Sin}(0.5634\pi (t - 23)) + (0.1506 (y - 1879) + 540.4485)$$

Although the yearly rainfall still has some individual variation, the combination of 64-year, 17.5-year and 3.5-year cycles account for much of the rainfall variation at Dookie College (see Figure 4). These cycles are very similar to weather pattern cycles discovered by Mazzarella.

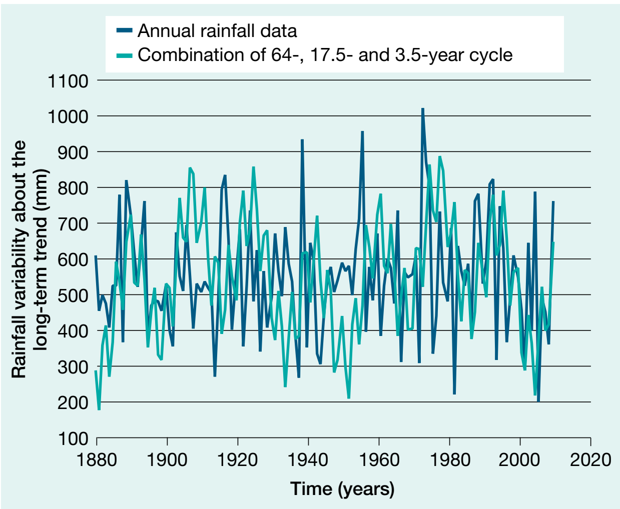


FIGURE 4 Comparison of annual rainfall data from the Dookie College weather station with the combined 64-year, 17.5-year and 3.5-year cycles

Observations and comments

Although there is still variability in rainfall from year to year, much of the long-term rainfall variability recorded at Dookie College can be attributed to medium-term or long-term cycles in the weather patterns. These cycles are similar in duration to other cycles found in weather data from other parts of the world. The troughs in the combined 64-year and 17.5-year cycles coincide with drier-than-average periods, while peaks coincide with wetter-than-average periods (see Figure 5).

The underlying cause of these rainfall cycles is still unknown, so to suggest rainfall can be accurately forecast based on mathematical equations alone would be foolish — however it appears rainfall in the Dookie district has regular cyclical patterns. Interestingly, these cyclical patterns correctly predict a series of drier-than-average years between 2000 and 2009 followed by a much wetter year during 2010 (see Figure 4) because the minima for both the 64-year cycle and the 17.5-year cycle coincide during this drier-that-average period (see Figure 5). According to the analysis, both cycles now appear to be increasing again, suggesting a return to more average rainfall for a period.

CONTACT

Graham Brodie

T: (03) 5833 9273

E: grahamb@unimelb.edu.au

Integrating dual-purpose crops — capturing the whole-farm benefits

John Kirkegaard [1], Hugh Dove [1], Walter Kelman [1], Susan Sprague [1], Peter Hamblin [2]
[1] CSIRO Canberra
[2] Agritech Research

Key points

- Success with dual-purpose crops requires best-practice crop agronomy and livestock management.
- Economic success at the whole-farm scale is driven by factors over and above the gross margin (GM) of individual dual-purpose paddocks and includes considerations of pasture spelling, increased winter stocking rates, widened operational windows, flexibility and risk management.
- Integrating dual-purpose cereals and canola can provide synergies at the whole-farm scale in disease and weed management in crops and pastures, broaden the feed-base options and operational windows for sowing, grazing and harvest.

Since the development of long-season and winter wheats for Australia, well-managed dual-purpose cereal crops have provided opportunities to increase profitability and flexibility of mixed farms, by increasing winter stocking rates and providing income from forage and grain.

In a similar manner, dual-purpose canola can generate benefits while providing a break crop for weeds and disease, to clean up paddocks for subsequent cereals or for pasture establishment. In combination with grazed cereals, grazed canola can also spread the timing of operations and potentially extend the grazing window.

Research carried out since 2004 has developed best-bet management strategies to maximise the chances of success with each option. Recently research has focussed on investigating and quantifying the benefits of integrating these options at the whole-farm scale, including productivity of crop and pasture phases, profitability, managerial flexibility and risk management.

In general, dual-purpose crops are an option for early sowing to allow biomass to accumulate for winter grazing, followed by 'lock-up' before stem elongation (cereals) or bolting (canola) to avoid yield penalties. Dual-purpose cereals and canola both provide additional forage to help fill the winter feed gap and can be grazed, cut for hay, silage, grazed out or grown on for high grain yield depending on seasonal circumstances.

This article covers current best-bet management guidelines for each crop, together with more recent observations, and then considers some of the whole-farm benefits from integration.

Dual-purpose cereals — best-bet management

Wheat, oats, barley and triticale are the crops most commonly used as dual-purpose cereals. For the most part, the choice is an agronomic one although current grain prices favour the use of dual-purpose wheat. Similarly, the choice of cultivar is also an agronomic decision, though long-season or true winter types will provide a more flexible fit into a dual-purpose system.

After these decisions are made, there are a number of key points to ensure best-bet management of a system based on dual-purpose cereals including:

- **Sow early (March if possible) with a long-season or true winter variety.** Early-sown wheat is exposed to greater risk of wheat-streak mosaic virus (WSMV) but evidence suggests this is related to paddock hygiene during the preceding summer. Strict attention to paddock hygiene, or sowing wheat after canola, will reduce the risk of WSMV.
- **Leave post-sowing nitrogen (N) applications until after grazing or at least, do not apply just before grazing because of the risk of high forage nitrate levels.** Untimely nitrogen applications can lead to nitrite toxicity in livestock, especially under cool, cloudy conditions. Researchers have found it beneficial to apply 50kg of nitrogen as urea, as soon as possible after grazing finishes.
- **Start grazing as soon as cereal plants are well anchored (the 'tug test') and when there is more than one tonne of dry matter per hectare.** The decision about when to start grazing is much less important than the decision about when to stop.
- To determine stocking rates for cereal grazing, a useful rule-of-thumb is to graze cereals with about 1000kg of live animal/ha (for example, 33 sheep/ha each weighing

30kg or three beasts/ha each weighing 333kg). This seems to result in about a month's grazing. Provided livestock are removed before a critical crop growth stage (see Figure 1) it is likely that across a wide range of stocking rates, there will be little effect of the grazing on ultimate grain yield.

In trials, the number of sheep grazing days per hectare obtained from crop grazing ranged from 1000 during a dry season (2006) to 1500 during an excellent spring (2005). Typically, crop grazing results in 1000–2000DSE grazing days/ha and provides $150–450/ha higher paddock gross margins than a grain-only crop.

- Timing stock removal is more important than stocking rate. Remove stock before the crop reaches first node stage (GS31), to minimise the effects of grazing on grain yield.
- Wheat forage has a high potassium (K) content (3–4% of DM) and a very low sodium (Na) content (often <0.02% DM), which results in a high K:Na ratio. Although the magnesium (Mg) content of wheat forage (about 0.1–0.15% DM) is usually slightly above the value needed by animals for growth (0.08% DM), the high dietary K:Na ratio greatly reduces magnesium absorption in the gut. Subsequently, supplementing sheep or cattle grazing wheat with sodium and magnesium (for example, with a 1:1 mix of granular salt and Causmag) at a rate to allow mineral supplement intakes of 20g/d (sheep) or 140g/d (cattle). Supplementation is inexpensive and in grazing trials, has resulted in increases in liveweight gain from 20–100%, far in excess of the cost of supplements.
- Mineral supplements are not required for livestock grazing oats, barley or canola because of their much higher forage sodium contents. Responses to supplementation with triticale have been variable, reflecting the variability in its sodium content. Supplementing livestock grazing triticale is probably cheap insurance.

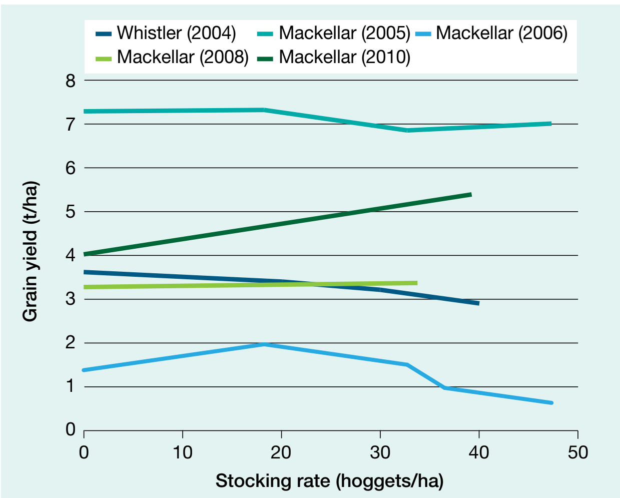


FIGURE 1 Effect of grazing on yield of dual-purpose wheat at a range of stocking rates

- Grazing cereals can contribute to in-crop weed control during winter–spring. In Canberra during 2010, grazed Mackellar$^{\Phi}$ wheat yielded 33% more grain than ungrazed (see Figure 1), partly due to weed competition in the ungrazed crop. At harvest, weed levels (mainly annual ryegrass) of grazed and ungrazed crops were 2% and 10%, respectively, of the pre-harvest dry weight.

Dual-purpose canola — best-bet management

- Sow early (late March to mid-April) with a long-season variety. Be prepared, ensure adequate soil moisture, use press wheels to improve establishment in dry conditions.
- Use sowing rates that will achieve optimum density (at least 50 plants/m^2) and ensure adequate fertility for strong early growth. Delay nitrogen topdressing and some weed control until after grazing. Do not apply nitrogen just before grazing to avoid the risk of toxicity in livestock.
- Use varieties with high early vigour and good blackleg resistance (R rating). Grazing can increase the incidence and severity of blackleg. When considering insect and weed management, keep in mind the withholding periods for any chemicals used.
- Grazing can start when plants are well anchored, biomass is adequate (~1.5 t/ha), and withholding periods have been met. This usually means grazing from mid-June or 6–8 leaf stage for April sowings.
- Canola produces quality feed and high liveweight gains (200–300g/day). Where grazing guidelines are followed, few animal health issues will occur (see comment about nitrogen fertilisers). Expect 600–800 DSE grazing days/ha (4–6 weeks @ 25 DSE/ha) in the period mid-June to late-July, though considerably higher grazing days have been observed.
- Ensure adequate livestock are on hand to capitalise on this high-quality feed. The choice of enterprise and class of animal will determine the profitability of dual-purpose canola use (for example, cross-bred lambs vs breeding Merinos).
- As with dual-purpose wheat, timing of stock removal from canola is a key decision and more important than the timing of the start of grazing, or even the stocking rate used! To avoid yield penalties, remove stock before buds have elongated more than 100mm above ground level.

- Assuming best-bet management, paddock gross margins for dual-purpose canola are generally $100–400 more than for grain-only canola, but this is price sensitive.

Indirect benefits of dual-purpose canola

Specific indirect benefits of dual-purpose canola, compared with grain-only canola, include the reduction in the height and bulk of vigorous high-yield potential crops, facilitating ease of windrowing and harvest. This provides a considerable economic saving and reduced lodging risk in high-yielding years (such as 2010).

Dual-purpose canola also provided producers with a high-value alternative to dual-purpose wheat when WSMV prevented early (March) sowing after 2005.

The use of dual-purpose canola in the year before dual-purpose wheat will also greatly reduce the chance of WSMV infection in wheat.

Potential risks of dual-purpose canola

Not thinking ahead — ensure the paddock is suitable and ready for an early sowing opportunity. Select varieties that provide suitable weed control options in relation to withholding period. Calculate and determine stock numbers required to make money from the feed — consider the cost and potential margins available if additional stock need to be purchased.

Sowing the wrong variety too late — only early-sown crops provide a grazing opportunity. Select a vigorous variety that is highly blackleg resistant, and ensure you can meet herbicide withholding periods.

Grazing too late — lock up the paddock before the buds are elongating and being eaten by stock (>100mm) to avoid yield loss, or weigh up the value of the extra feed vs grain income.

Cereal grazing vs canola grazing

Cereals and canola do not compete as grazing options within the total farm feedbase, but are complementary, generating flexibilities in sowing and grazing windows. They can be grazed in sequence, extending the period for which pastures are spelled during the critical winter–early spring period.

The initial biomass production of cereal and canola crops is similar, but canola does not recover as quickly from grazing. In a farm system that includes both, graze canola first and allow time for recovery, either for further grazing or seed production.

Indirect benefits — whole-farm integration

If yield penalties from grazing are avoided, then increased gross margins per hectare for dual-purpose vs grain-only paddocks of either cereals or canola are possible. However, there can be even greater benefits at the wider system or farm scale resulting from complementarities between cereal and canola, and from the spelling of pasture, which occurs during crop grazing.

Pasture spelling (the Stockade Experiment)

Intuitively, crop grazing during winter should provide a period of 'pasture spelling' which, if substantial enough, could provide a 'wedge' of late-winter feed for livestock. A trial in Canberra during 2010, quantified the value of spelling a phalaris-subclover pasture during winter grazing of either a wheat crop alone (Mackellar [ф]), a canola crop alone (Maxol), or a sequence of the canola and wheat, all grazed by Merino hoggets. Researchers recorded the extra grazing days obtained through crop grazing, compared with continuously grazed pasture. The extra pasture production was then evaluated for each of the crop-grazing treatments in terms of extra grazing days achieved compared with a continuously grazed pasture (see Table 1).

Compared with the extra grazing days of about 800–1200 afforded by grazing a single crop compared to continuously grazed pasture, grazing both crops in sequence allowed almost 2100 extra grazing days.

Removing stock from pasture for crop grazing resulted in extra pasture growth (data not shown) and substantially more pasture-grazing days post-crop. Of the total extra SGD/ha of 1500–1700 (one crop) or 3456 (both crops), no less than 30–47% arose from the effect pasture spelling. This is a substantial extra benefit to be gained from dual-purpose crop grazing.

Management considerations — whole-farm integration

(i) Weed and disease control

Growers using dual-purpose cereals, especially in higher-rainfall zones, will encounter difficulties in

TABLE 1 Extra sheep grazing days (SGD/ha) obtained by grazing wheat, canola or canola+wheat in sequence, and the extra sheep grazing days obtained by the subsequent grazing of winter-spelled pasture (all relative to continuously grazed pasture)

Treatment	Crop extra SGD/ha	Pasture extra SGD/ha	Total extra SGD/ha	% of total from extra pasture
Wheat grazing	1188	521	1709	30.5
Canola grazing	822	739	1561	47.3
Canola+wheat	2076	1380	3456	40.0

managing root and leaf diseases or grass weeds without a 'break' in the sequence of cereals and grass-based pastures. The combination of canola, wheat and pasture provides an effective management tool to manage persistent weeds and diseases for both higher cereal yield and more successful establishment of perennial pastures.

(ii) Flexibility and risk management

Both cereals and canola sown early for grazing can be managed according to the seasonal outlook, providing opportunities to manage weather-related risks and commodity prices.

Winter grazing provides earlier income to cover establishment costs and grazing can be managed according to the relative prices for crop and livestock products as the season unfolds.

The risks of frost damage or spring drought can also be managed with options for silage or hay in flowering crops, hay or salvage grazing. In severe droughts or frosts where most crops fail, grazed crops will have already provided some income to offset losses.

(iii) Livestock management consequences and benefits

To capture the benefits of the extra sheep grazing days afforded by grazing systems based on pastures plus crops, growers need to either have extra animals or obtain the money required to buy them. The possible costs of obtaining extra animals needs to be factored into any whole-farm comparison of grazing options.

Grazing of dual-purpose crops may permit a re-evaluation of calving or lambing times. In sheep-grazing systems, a potential problem with autumn lambing is that lactating ewes, or their early-weaned lambs, enter the winter period with high nutrient demands but scarce pasture supply. One unexplored consequence of grazing systems involving pasture plus crop is that crop grazing allows autumn lambing by overcoming this feed shortage, with a resultant longer period to finish weaned stock for market.

Similarly, if crop grazing is a major component of the system then there may also be consequences for helminth (worm) control, to the extent that the crop itself and possibly the spelled pasture could substantially be free of helminth larvae.

An example of whole-farm integration

An assessment of the potential whole-farm impact of grazing crops on a 1300ha mixed farm in the Young district of southern NSW is shown below. It considers some, though not all of the effects of crop grazing discussed. It uses on-farm agronomic and economic data derived from clients of DeltaAgribusiness over the seasons 2000 to 2006.

This scenario (see Table 2) integrated grazing wheat and canola into the farm enterprise by replacing 100ha of grain-only wheat with dual-purpose wheat, and 50ha of dual-purpose oats and 50ha of grain-only canola with dual-purpose canola.

In the case of the oats it was assumed the grazing value of oat sand canola is similar and the increased gross margin ($180/ha) comes from the higher-value canola grain ($240/ha GM for oats vs $440 for canola). This represents a potential $9000 increase in farm profits in years where this can be achieved.

In the case of dual-purpose canola and wheat replacing grain-only crops, it was assumed a $200/ha increase in GM from the grazing value on the crop was possible. There also was added an estimate from the benefits of pasture spelling while the 150ha of crop was grazed, based on experimental evidence in 2010 (see Table 1). Many additional system benefits, including control of herbicide-resistant weeds, were difficult to quantify.

For the 150ha increase, this represents an increase of $5000 to $18,000 in farm profits. Together, these two changes represent a potential $14,000 to $27,000 increase in years where grazing canola can be adopted. Assuming this is two-third of years (based on experience with grazing cereals) this represents an average potential gain in farm profit of $10,000 to $20,000 depending on the type of animal enterprise.

Based on average farm profits of $200,000 for mixed farms in the area (Holmes and Sackett, 2007) this is a 5–10% increase in average farm profits.

TABLE 2 An example of the potential change in enterprise area for a 1300ha mixed farm near Young in southern NSW following integration of dual-purpose canola

Enterprise	Current (ha)	New (ha)	Potential benefit
Pasture	620	620	Spelling benefit on 150ha
Grain-only wheat	350	250	No net difference/ha
Grain-only canola	200	150	No net difference/ha
Dual-purpose wheat	0	100	Increase GM $200/ha on 100ha
Dual-purpose oat	50	0	No difference (replaced by canola)
Dual-purpose triticale	80	80	No difference
Dual-purpose canola	0	100	Increase GM $200/ha on 100ha
Total grazed crop	130	280	Pasture spelling benefit on 150ha
Total grazed area	750	900	
Winter DSE/ha	12.1	12.4	Increase in farm stocking rate



Winter stocking rates

On mixed farms, the profitability of the grazing enterprise is determined largely by the winter stocking rate. Dual-purpose crops accumulate more biomass and can carry more stock than pastures during these winter months and grazing the crops provides a period to allow the pastures to recover, together reducing the risk of costly supplementary feeding.

The dual-purpose crops are a risk management tool, securing income from dry matter when rainfall is sufficient and providing flexibility to produce hay, silage or trade livestock on spelled pasture if the spring season is bountiful.

Other obvious, but difficult to quantify, 'system' benefits of a dual-purpose canola include an improved ability to control herbicide-resistant ryegrass and the potential disease break effects for subsequent cereals. At present the loss of dual-purpose wheat due to WSMV (not considered in Table 2) provides further opportunity for higher-value dual-purpose canola to fill the gap. These types of economic analysis will be specific to each region and sensitive to assumptions about the frequency and area of dual-purpose crops which can be grown.

CONTACT

John Kirkegaard
CSIRO Sustainable Agriculture
National Research Flagship
T: (02) 6246 5080
E: john.kirkegaard@csiro.au

Hugh Dove
CSIRO Plant Industry
T: (02) 6246 5078
E: hugh.dove@csiro.au

MORE INFORMATION

These issues are considered in further detail, with additional data, in Grains Research and Development Corporation (GRDC) Update papers by Kirkegaard *et al*. (2010), Mason (2010), Kirkegaard *et al.* (2007) and in the comprehensive *GRDC Canola Guide* (2009).

Can livestock have a long-term role in no-till cropping systems?

James Fisher [1], Peter Tozer [2], and Doug Abrecht [3]
[1] Désirée Futures, York, WA
[2] PRT Consulting, West Wyalong, NSW
[3] DAFWA Northam, WA

Key points

- Livestock are an important source of farm diversification and risk management. While net farm income tends to decline as the proportion of livestock increases, variation in net farm income also decreases, reducing volatility in revenue.
- Negative impacts of livestock on soil structure and surface cover must be balanced against consumer demands and constraints of no-till cropping (weed control issues, lack of soil cover, disease).
- Impacts of livestock, such as nutrient redistribution to livestock camps, are likely to be overestimated. Adaptation through rotational grazing or livestock removal/ agistment can improve integration.

Mixed farming incorporating annual cropping and ruminant livestock is practised widely across Australia's grainbelts, accounting for almost half of the country's farm enterprises. The combination of favourable crop prices relative to livestock values, improved seeding technology, more specialised crop production and autumn–winter rains that support good crop establishment, has seen an intensification of cropping during recent decades.

No-till cropping systems have many advantages including improved soil physical structure, timeliness of seeding, and improved soil water storage, especially at sowing. Further benefits from no-till cropping may come from combining full stubble retention and disc openers with precision cropping and controlled traffic.

There is renewed interest in livestock's value as a risk management tool due to escalating crop input costs, climate variability and improved meat prices. This raises questions regarding the 'fit' of livestock with highly-developed, no-till cropping systems.

The aim of this project was to determine whether there is a long-term role for livestock in combination with no-till cropping systems. This paper presents results from a review of livestock impacts on no-till systems, highlighting trade-offs, options for managing the impacts and further research needs.

Method

A review of the impacts of livestock on crop production, particularly no-till systems, was carried out. The work principally comprised a scientific review, but also included focus groups and an economic analysis utilising data from case studies. This paper largely considers the findings of the review; the full report, including case studies and detailed economic analysis, is available through the Grains Research and Development Corporation (GRDC).

The scientific review, largely focussed on work from western and southern Australia, covered the impact of livestock on ground cover, soil compaction, soil water, nutrient cycling, pest management, biodiversity and crop production.

Focus groups attended by 39 participants (4–12 per workshop) were carried out at five locations across the southern Australian wheatbelt (Kojonup and Northam in Western Australia, Osborne in New South Wales, Birchip in Victoria and Riverton in South Australia).

Focus group participants provided qualitative and semi-quantitative information regarding their experiences and perceptions of the trade-offs between livestock and cropping, especially no-till cropping.

Consultants from four regions in Australia (the northern and southern wheatbelts of WA, SA, and western Victoria) provided information regarding three farming systems in their area (prices and yields for crops and livestock; farm capital, including farm land, machinery and livestock value; operating expenses, including fixed and variable costs).

The consultants provided yield and price data at expected, pessimistic and optimistic levels. This information was used to calibrate a whole-farm budget for 10 of the farms. For each farm 10,000 iterations were run, using a simulation program called Crystal Ball 2000, from which mean net farm income and variance measures of net farm income for each farm were produced.



Results and discussion

Livestock have positive and negative impacts on no-till cropping systems (see Table 1). The review described and, where possible quantified, these while exploring options to manage them.

Key trade-offs, and management options

Removal of ground cover (crop residues) and the compaction of soil due to grazing and trampling are the two major limitations to the incorporation of livestock with no-till cropping. Management options to address these may include the use of rotational grazing with strict action thresholds for minimum levels of ground cover and/or soil condition (especially wetness) combined with close monitoring of individual paddocks, or the removal of livestock to sacrificial paddocks, confinement feeding areas, other geographic locations (for example, agistment) or complete removal from the farm.

The pasture–livestock phase of mixed farms is important in increasing organic matter content of the soil and associated biological activity and in supplying nutrients, principally nitrogen (N). Soil organic matter increases under long phases of legume pasture. It does not increase with pastures of shorter duration (≤ 2 years), tending to remain stable or decline (though at a slower rate than continuous cropping).

Legume-based pastures supply an average of 21–27kg nitrogen fixed per tonne of above pasture dry matter (DM). This contribution is increasingly important as the cost of manufactured fertiliser increases. There are negative impacts of grazing associated with the redistribution of nutrients to stock camp areas and losses due to volatilisation from

TABLE 1 Impacts of livestock (positive and negative) on key aspects of mixed-farming systems and options to manage them

Aspect	Positive impact	Negative impact	Management options
Ground cover	Utilisation/management of stubble	Removal of ground cover, trampling, erosion risk	Address feed gaps and maintain ground cover (options such as perennial pastures, summer fodder crops or dual-purpose crops); ensure summer cover levels above 50% (1t/ha DM stubbles or 750kg/ha for dry pastures); grazing management or removal of stock to maintain ground cover
Soil compaction	Compaction shallower and over smaller area than machinery (if not control traffic)	Decreased pore space, increased bulk density, decreased infiltration, remoulding	Prioritise maintenance of pasture cover in grazing management decisions
Soil water	Decreased recharge, lowering of water tables	Drying of soil profile, decrease in crop yield (e.g. lucerne)	Integration of perennial pastures and crops — current options largely restricted to high-rainfall areas
Nutrient cycling	Supply of nitrogen, increased soil organic matter, increased biological activity	Redistribution of nutrients to stock camps	Employ more intensive grazing management (e.g. rotational grazing) to control livestock nutrient deposits; include a wider range of pasture plants in the diet or use feed supplements to modify grazing patterns
Pest management	Control of weeds, reduction of stubble and soil- borne diseases	Redistribution or burial of weed seeds, reduction in beneficial species	Uphold crop hygiene including withholding periods of up to 10 days (re-distribution of weed seeds), control seed-set with grazing (possibly in combination with burning of chaff dumps), employ good husbandry practices (e.g. shearing before seed-set); monitor timing and intensity of grazing to minimise impacts on beneficial species (especially invertebrates)
Biodiversity	Build-up of organic carbon, greater biodiversity compared with crop	Decreased species abundance and diversity	Maintain native perennial grasses in pastures (productivity, water use, biodiversity benefits); target use of phosphorus fertiliser (soil tests); reduce inputs and grazing intensity in areas inhabited by high-value native grassland; maintain connected habitats (e.g. linked shelterbelts)—encourages beneficial predatory species
Economics	Lower variability in income	Lower income compared with cropping	Reduction in variability of net farm income most evident where livestock contributes ≥ 15% farm income

urine patches. While commonly accepted and supported by research, previous assessments have come from small plots or simulated urine patches and so may be an over-estimate. The pattern of nutrient returns from livestock may be improved by grazing management, mix of pasture species and precision livestock management, but further research is needed to confirm this.

Grazing livestock provide an important option for the management of pests of cropping, particularly herbicide-resistant weeds. Managing the timing of grazing relative to the seed-set of weed species and observing withholding periods following the grazing of paddocks with a high weed burden is required to ensure seeds of weeds, or volunteer crops, are not spread in faeces. Grazing livestock in association with connected shelterbelts can form part of integrated pest management programs, but more work is needed to confirm the benefits for complexes of pest species and to assess the impact on overall farm productivity and profitability.

Systems incorporating livestock add flexibility and may improve soil water use and profitability. Perennial pastures in farming systems may address episodic recharge, but current options are limited to the medium–high to high-rainfall areas. Similarly, options for dual-purpose crops, which are a useful and profitable means of integrating cropping and livestock, are currently restricted to high-rainfall zones. Clearly there is a need to expand options to all rainfall zones and regions if such benefits are to be realised.

In practice

Growers in the focus groups had farms that were at least 70% arable. Since the 1990s the proportion of arable land used for livestock has decreased from 40–60% to 0–30%. This proportion is expected to remain low or decrease further during the next 10 years. For most of the growers these changes are not seen to lead to complete removal of livestock. At most workshops there was at least one grower who intended to get out of livestock altogether and also at least one who intended to keep a higher proportion of livestock than the rest of the participants.

The relative returns of crop and livestock have principally driven the changes in the proportion of livestock while personal preference is a major factor in the decision to maintain or remove stock altogether.

Those who had completely removed livestock focussed on the efficiency of cropping (and had a general cropping focus), the need to maintain cover, concerns over erosion and other factors (for example, labour, mulesing, emissions trading). The 100% croppers manage risk with different crops, marketing and possibly different times of planting. Cropping is recognised as high risk, but also high reward and livestock are considered to compromise sound crop management. Those with a mixed system focussed on diversity of enterprises and spreading risk. The relative profitability and viability of grazed pasture compared with crop legumes is an important factor keeping livestock in the system.


Photo: Catriona Nicholls



Economic analysis

The economic analysis highlighted the trade-off between income and income variability in mixed farms. Correlation analysis of the results was used to study the relationship between return on assets (ROA), coefficient of variation of net farm income (CV of NFI) and percentage of income from livestock. The correlation between ROA and percentage of income generated from livestock was -0.75, indicating that as livestock increases in the farming system ROA declines. The correlation between the percentage of income generated by livestock and the CV of NFI was also negative (-0.70) indicating that livestock tend to reduce the variability of NFI. The decrease in the variability of NFI is most evident where livestock contributes a significant proportion of income (see Table 1).

Discussion

Livestock may be combined with no-till cropping systems. Triple-bottom-line gains can be realised through improved management of grazing practices and livestock production, attention to pasture management, a move away from a 'stock and forget' approach to sheep management and implementation of precision livestock technologies. The 'fit' of livestock in a no-till system will be determined by the productive capacity of the land and relative profitability of cropping and livestock, the management of herbicide-resistant weeds, sensitivity of soil to damage from grazing and trampling and the farmer's passion, preference and willingness to apply increased management to livestock.

ACKNOWLEDGMENTS

Thanks to focus group participants and the local contacts who assisted with them, our workshop facilitator, David Beurle, the consultants who contributed case studies, various authors, researchers workers and supporters of the research used and the GRDC for commissioning and funding the work.

This paper was originally presented at the GRDC Crop updates in Perth and Kojonup, Western Australia.

The final report from this project and a related fact sheet are available at:
www.grdc.com.au/uploads/documents/GRDC_Review-of-Livestock-Impacts-On-No-Till-Systems.pdf

www.grdc.com.au/uploads/documents/GRDC_FS_MixedFarming.pdf

CONTACT

James Fisher
Désirée Futures, York WA
E: james@desireefutures.net.au,

Peter Tozer
PRT Consulting, West Wyalong NSW,
E: prt_consulting@live.com.au

Doug Abrecht
DAFWA, Northam WA
E: doug.abrecht@agric.wa.gov.au

Farmers' attitudes to adoption of genetically modified (GM) canola in Victoria

Graham Brodie and Ciara Cullen
The University of Melbourne

Key points

- Interviews of a diverse group of 30 farmers revealed that 73% believe GM technology is good and 27% believe it is excellent.
- The biggest perceived benefit to growing GM canola was weed control according to 90% of farmers interviewed.
- All interviewees indicated their biggest concerns with GM were the negative public perceptions, marketing and the control that multi-national companies have over the technology.
- The farmers concluded that multi-national company control is perhaps why there is low adoption of the technology in Australia; however, 80% of farmers who will not grow GM said they are content with their current varieties.

Aim

To understand the attitudes of farmers to the adoption of GM canola in Victoria

Method

A total of 30 broadacre farmers from throughout Victoria were interviewed to assess their attitudes to GM technology.

Each farmer was allocated into a group based on their use and experience with GM canola to date. The three groups were: farmers currently growing GM canola, farmers who have not grown, and will not grow, GM canola, and farmers who will potentially grow GM canola in the future.

Separate interview questions were written for each group. Some questions were common to all groups for easy comparison and some questions were appropriate for each individual group.

The farmer group who currently grow GM Canola provided information from their experiences. The specific questions for this group indicated what was involved in growing a GM crop in terms of: farm management, pricing, segregation, and marketing. This group also provided information about where they see the biggest constraints with the technology and why uptake is low among other farmers.

The second farmer group consisted of those who have not and will not grow GM crops. The specific questions for this group investigated what they believed were the inhibitors of the technology and reasoning behind their decision. Questions also covered aspects such as costing, marketing, quality assurance, where they receive their information, and where they see the need for improvements.

The third group consisted of those who could potentially grow GM crops in the future. The specific questions for this group investigated what farm practise challenges growing GM canola will bring. They were also asked where they gain their information, factors influencing them to grow GM crops and the benefits they are hoping to achieve.

Results

Most of the 30 farmers were between 51–60 years of age. Of the 30 farmers, no-one perceived GM technology as being a poor option, with 73% of the farmers believing the technology was good and 27% thought it was excellent (see Figure 1).

The biggest factors farmers believe affect the adoption of GM are: education of the public, control of the technology by multi-national companies, and marketing (see Figure 2).

Of the farmers interviewed, 70% would like to see a drought tolerance trait developed in GM crops, while 63.3% would

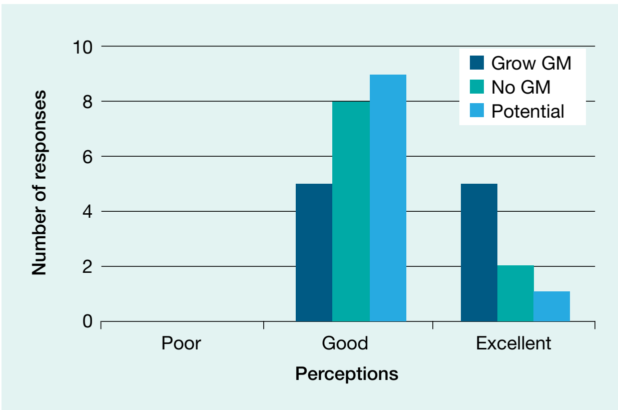


FIGURE 1 Farmers' perceptions of GM technology



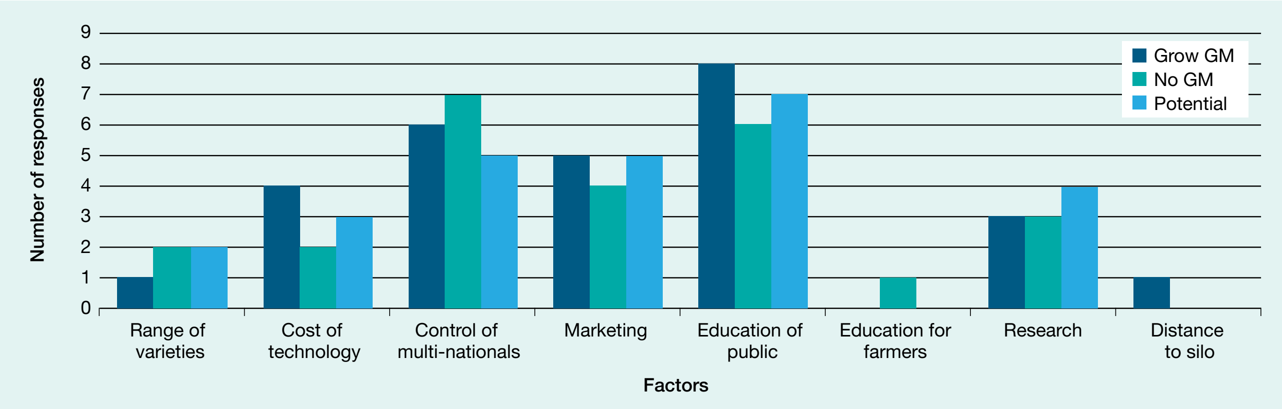


FIGURE 2 Factors believed to be affecting the adoption of GM technology

like to see increased yield and disease resistance as traits in a GM crop (see Figure 3).

All of the farmers growing GM canola source some of their information from an agronomist. The next source of information was from grower groups, where 50% of farmers gain some information. Weed control is the main benefit current GM canola growers see with 90% of farmers choosing this option.

The biggest reason for the non-GM growers not growing GM canola was because they were content with their current varieties. About 30% of these farmers are not growing, and will not grow, GM crops because they are waiting for more research to occur; or they think the cost of production is too high and they would like to observe other farmers' experiences.

Of the 10 farmers in the group who plan to grow GM canola in the future, 90% indicated increased weed control was the main factor influencing their decisions.

Observations and comments

The factors the interviewed farmers believe are affecting the adoption of GM canola and technology are: consumer education/negative public perceptions, control from multi-national companies, and marketing. If these issues were dealt with then there may be an increase in the use of the technology.

There were a number of farmers in all groups who believed research was inhibiting the adoption of GM technology — research is being carried out on GM crops, however many of the interviewed farmers believed there is simply not enough research being carried out.

Farmers believe the high cost of production of GM technology — the seed — was a contributing factor to poor uptake.

Genetic Modification is a technology all the farmers interviewed believe is good. As one farmer said; *"It has the potential to change the agricultural industry in a very positive way"*.

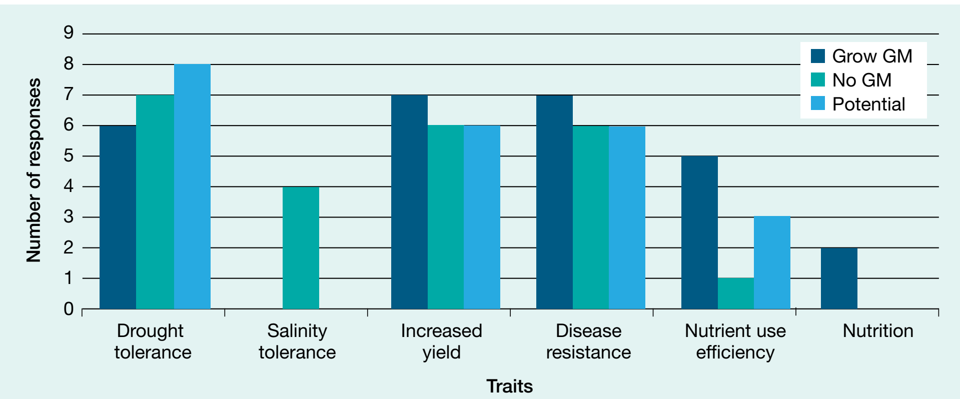


FIGURE 3 Traits that farmers would like to see in GM technology

CONTACT

Graham Brodie

T: (03) 5833 9273

E: grahamb@unimelb.edu.au

Time to check, take stock and re-think

Peter Botta
PCB Consulting

Now is the time to check grain storages — many growers are finding insect infestations in their storages.

A minor insect infestation can multiply rapidly — under ideal conditions the life cycle of insect pests may be as short as four weeks. Inspecting grain regularly ensures growers can effectively deal with any insects that may emerge.

Treating an infestation takes time and there are no 'quick' fixes growers can use.

Identify before treating

To maintain grain quality and to select the correct treatments, identify pests early by sampling monthly.

Sieve samples of grain taken from the top and bottom of stores. Sieving samples onto a white tray will make it easier to see small insects. A magnifying glass makes it easier to identify pests — holding the tray in sunlight helps encourage movement for easier identification.

A warm clean glass container helps to identify grain pests — weevils and saw-toothed grain beetles can walk up the walls of the glass easily, flour beetles and lesser grain borer cannot.

If holes are bored through the grain the intruders are either lesser grain borers or weevils — both pests inflict this type of damage.

Some growers insert a temperature probe into the grain mass to detect any 'hotspots', which can indicate insect activity or mould growth.

Treatment options

Dichlorvos used in unsealed storage will kill detected insects. The rate for the lesser grain borer is different than for other storage pests, and has a withholding period of 28 days. The withholding period for the other insect pests is seven days due to the different rate used. Spray Dichlorvos onto grain as it is moved to another storage. Dichlorvos will kill insects in the grain but will provide no further protection. If grain is to be stored for longer, retreat it with a protectant.

Growers with gas-tight sealed storage (typically silos) can fumigate grain and be sure they have controlled all insects (eggs, larvae, pupae and adults) present.

Do not use phosphine in unsealed storages — at best only adults will be controlled, and the practise is causing serious resistance problems for growers.

Maintaining phosphine as a viable treatment should be the goal of every user because it provides growers with an inexpensive, effective and easy to use treatment for killing insects when used in gas-tight sealed storage.

Take stock to prevent resistance

Growers need to take stock of their storage management practises and system. One of the many challenges facing growers with unsealed storages is resistance to protectants (Reldan®, Fenitrithion®, and Methoprene®) and Dichlorvos in the lesser grain borer.

Borers are typically the major pest problem in south-eastern Australia and can quickly ruin stored grain.

Growers will be forced into having some gas-tight sealed storage to control an insect infestation as Dichlorvos has been withdrawn from on-farm use. There is a two-year phase out period.

For effective control of any insects detected in storages, fumigating in gas-tight storages will be the only option. While there are many storages bought with aeration, it will not kill insects although it will help manage and limit insect reproduction and multiplication in store.

Implement strict grain hygiene practises, use aeration with an automatic controller and if and when an infestation occurs, treat it with phosphine in gas-tight sealed storage.

Gas-tight gives confidence

When buying new storage, it makes sense to invest in gas-tight sealed storage. At least ensure some sealed storage is available so any insect problems can be shifted into and fumigated in gas-tight storage.

One of the worst things growers can do is think they are buying storage they can fumigate in only to find it isn't gas-tight.

There is a lot of misconception about the term sealed. Sealed can mean many things to different people, when buying sealed storage it is imperative it is gas-tight.

Gas-tight storage ensures the structure will work as a fumigation chamber — the whole aim of having it.

Having a sealed structure will not automatically mean successful fumigation. The only way to know whether a silo or any storage system is gas-tight is to pressure test it.

Starting oil level.

Pressurise silo to create a difference in oil levels of 25mm.

The time taken for the oil levels to drop from 25mm apart to 12mm apart must be no less than five minutes on new silos. For older silos, three minutes is acceptable.

Photos: Chris Warrick

FIGURE 1 Carrying out a five-minute half-life pressure test

The standard pressure test requires that the silo meets a five-minute half-life pressure test (see Figure 1). When buying a new gas-tight sealed silo always insist it meets the Australian standard AS 2628-2010, which is based on the five-minute pressure test.

Making phosphine last

Phosphine resistance is a serious threat to Australia's grain industry. Resistance is really a symptom of a deeper problem caused by phosphine use in structures that are not gas-tight, or when used at off-label rates or for insufficient periods.

Ensuring phosphine is used only in gas-tight structures at label rates and for recommended fumigation periods will enable the industry to prolong the use of this important insect-control tool.

The first step for growers is to ensure existing and new storages are gas-tight using the standard pressure test.

After testing the silo, and it has met the pressure test, always follow label directions when using phosphine.

Correct dose rates and exposure periods are essential. The exposure period is determined by temperature:

- Recommended minimum exposure period:
  - Seven days when temperature is above 25ºC.
  - 10 days at 15–25ºC.

  Do not fumigate when grain temperatures are below 15ºC.
- Ventilation period:
  - Four hours with fans.
  - Up to five days without fans.
- Withholding period:
  - Two days after the ventilation period (human or stockfeed).

Existing storage — the options

When considering grain storage many growers will have some existing storages. Growers know from experience which storages have problems and when they occur.

Empty first those storages that are prone to insect infestation within a short timeframe.

Fitting aeration onto existing storages is one way to assist in managing insects and quality. Having some gas-tight sealed storage ensures any infestations can be managed when they occur.

Planning a storage system is the key to successful grain management. Thinking about the pros and cons of existing and potential storages is important. Putting together an overall plan including grain hygiene, treatment options, treatment usage, monitoring and overall maintenance of the system will ensure a quality product can be delivered.

Now is a good time to check, take stock and re-think all grain storage systems. Getting it right will ensure growers can deliver a quality product to the end-user.

CONTACT

Peter Botta

M: 0417 501 890

E: pbotta@bigpond.com

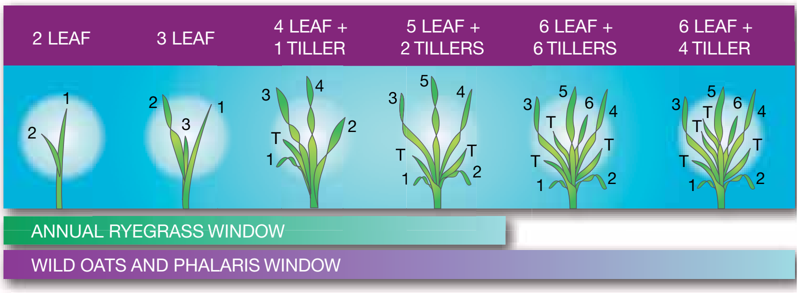
ADVERTISEMENT

AXIAL®: Puts more $$$ in your pocket

Annual Ryegrass (*Lolium rigidum*), Wild Oats (*Avena fatua* and *Avena sterilis*) and Phalaris (*Phalaris paradoxa* and *Phalaris minor*) are some of the most competitive weeds of cereal crops.

Cereal cropping favours the development of these grass weeds, their germination and vigorous growth and if combined with their high seed populations from preceding crops or pasture, can often lead to large reductions in potential yield. Annual Ryegrass and Wild Oats species exhibit staggered germination which often leads to very poor cultural control.

GRASS DEVELOPMENT STAGES



When these weeds emerge in crops, the best results for both controlling and maximising the yield potential of your crop is to control them in the first few weeks because of their competitiveness with your crop and potential to limit the yield.

Primary Industries South Australia developed a calculator that indicates the potential yield gain by controlling grass weed populations at various growth stages of the crop. The charts below are the potential yield gains predicted in a 2 t/ha wheat crop, by controlling certain grass weeds at varying grass weed plant densities.

Ryegrass (*Lolium rigidum*)

Growth Stage of Crop	Grass Weed Density/m²			
	50 plants/m²	100 plants/m²	200 plants/m²	300 plants/m²
	Percent yield gain from controlling grass weeds			
Pre-tillering	11.5%	20.0%	30.0%	35.0%
Tillering	10.0%	17.5%	26.0%	30.0%
Mid-tillering	8.5%	13.0%	19.0%	22.0%

Wild Oats (*Avena* spp.)

Growth Stage of Crop	Grass Weed Density/m²			
	50 plants/m²	100 plants/m²	200 plants/m²	300 plants/m²
	Percent yield gain from controlling grass weeds			
Pre-tillering	17.5%	26.0%	36.0%	42.0%
Tillering	15.0%	23.0%	32.0%	36.0%
Mid-tillering	12.0%	17.0%	22.0%	25.0%

Annual Phalaris (*Phalaris* spp.)

Growth Stage of Crop	Grass Weed Density/m²			
	50 plants/m²	100 plants/m²	200 plants/m²	300 plants/m²
	Percent yield gain from controlling grass weeds			
Pre-tillering	14.0%	22.0%	31.5%	38.0%
Tillering	12.0%	19.5%	28.0%	32.5%
Mid-tillering	9.5%	15.0%	20.0%	23.0%

For further information please call the Syngenta Technical Product Advice Line on **1800 067 108** or visit our website at **www.syngenta.com.au**

syngenta



On-farm storage — be sure to reap the benefits

Peter Botta
PCB Consulting

The reasons to store grain on-farm are many and each storage option requires different systems and levels of investment.

Successful grain storage is being able to kill insects in a timely manner while maintaining grain quality during storage, so growers can deliver and meet customer requirements.

An easy-to-manage system is also important — one that allows growers to effectively manage grain hygiene, chemical application and grain quality.

Protectants vs fumigation

Grain protectants struggle to control the lesser grain borer. Dichlorvos is being withdrawn as an in-store insect control option and growers need to be able to keep all grain market options open.

Protectants, by their nature, leave a chemical residue on the grain. Fumigants, when used correctly, will control all life stages of insects and do not leave a chemical residue on the grain. It is likely that in the near future fumigants will be the main option available to kill grain storage insects. This will require a shift in the way grain is stored on farm, but will provide effective insect control and the ability to market pesticide-residue-free grain.

Aeration

Aeration is used to cool grain to help manage insects and quality. However, aeration alone cannot always be relied upon to manage insects to a nil live insect tolerance level, particularly when grain is stored long term.

However, aeration is an excellent tool to assist in managing insects and grain quality.

Planning

A plan is essential for successful grain storage. Know where your grain is, determine suitable protection periods for specific storages, record treatments, determine quality specifications and know when to check grain.

Often a storage site will increase in capacity over time and planning for expansion is essential.

Ensure any storage facility is easy to access and use. When considering new storages, plan for the end goal.

Storage time — match the system to the timelines

When looking at expanding a silo site, or storing grain, growers need to ask whether the grain is likely be in storage for longer than anticipated and whether they are certain of the market to which they will deliver.

There are many ways to store grain, the longer the storage period, the greater the risk of insect or grain quality damage.

Storing in a system designed for short-term storage can be a disaster if grain is held too long. The goal is effective grain management with a minimum of hassle.

Harvest logistic storage

Storing grain at harvest to keep headers operating is common. The key is to be sure grain is not stored for longer than six weeks if it is untreated or cannot be fumigated correctly.

Photo: Chris Warrick

If using silo bags this timeframe is extended to 3–4 months, however it is imperative the grain is insect free when loaded into the bag.

Sheds are often used at harvest, but if grain is to be stored for longer than six weeks it will require treatment before storing.

Ground dumping requires some preparation for best results, such as grading a site for evenness and drainage.

Silo bags also need a graded, well-drained site, that is fenced off to exclude stock and vermin. In some cases silo bags will require bird proofing.

Generally grain is not treated when ground dumped or put into silo bags. However, if it is to be stored for longer than six weeks consider some insect control.

The biggest problem growers face when intending to store short term is that grain is kept for longer than anticipated — 6–12 weeks becomes longer than 12 weeks and the grain has no or minimal insect protection.

Short-term storage (six weeks – three months)

Grain stored short term can be stored in unsealed storage, whether in sheds, silo bags or unsealed silos and gas-tight sealed storage.

If an infestation is detected in an unsealed system, use Dichlorvos to kill insects. However, expect poor control of the lesser grain borer due to resistance.

Ideally storage in gas-tight sealed and aerated storage is the best option.

Shed storage is problematic as they are usually not totally weather-proof and it is difficult to exclude vermin.

Medium-term storage (up to six months)

Generally on-farm medium-term storage is handled the same way as short-term storage, what changes is the rate used to treat the grain when using protectants.

If insects have been present in the grain, particularly as immature stages, a longer storage timeframe often means adults start to emerge during storage (this is happening earlier and earlier).

Again gas-tight sealed storages and aeration offer the best system to store grain in the medium term.

Long-term storage (longer than six months)

Long-term storage is becoming increasingly common on farm and requires a system that supports effective insect and quality control. For this reason unsealed storage, even with aeration, usually cannot deliver the required level of management.

With sealed gas-tight storage growers can confidently kill insects — aeration maintains grain quality.



Grain stored for longer than nine months will often need retreating, which in gas-tight storage can be done easily without moving grain.

In unsealed storage grain needs to be shifted and treated into another storage, which can be logistically difficult, particularly where large volumes of grain are stored.

Choosing the best system

A gas-tight sealed and aerated system provides the best and most efficient way to store grain. The success of any system depends on implementing sound grain and system hygiene practises.

Fumigating grain is a much easier practise than spraying chemical into an auger, is safer when used correctly, and allows growers to store grain pesticide-residue free.

Many growers have existing storages that can be aerated and or retrosealed to improve their ability to manage insects and quality. Weigh up the pros and cons of gas-tight sealed storage and aeration when buying new storages. Ask yourself the question, how will I effectively manage the system I have and am investing in, into the future?

Prevention is better than cure

Grain and storage hygiene underpins the success of any storage system. Thoroughly clean all handling equipment and storage systems of grain and residues and ideally treat with a structural treatment, such as an inert dust (for example, Dryacide®). Inert dusts are the only treatments that will control all grain storage insect species.

When thinking of investing in on-farm storage, have a plan, consider the options and be sure to reap the benefits.

More information on grain storage, aeration drying and cooling, and insect control can be found at www.storedgrain.com.au

CONTACT

Peter Botta

M: 0417 501 890

E: pbotta@bigpond.com

Notes



Notes

Notes

RiverinePlains

PO Box 386 Yarrawonga VIC 3730
T: (03) 5744 1713
F: (03) 5743 1740
E: info@riverineplains.com.au
W: www.riverineplains.com.au