2014 UPDATE
South Australia

Tuesday 25th and Wednesday 26th

February 2014

Adelaide Convention Centre, North Terrace, Adelaide

Share knowledge – accelerate adoption

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Welcome

Australia in many spheres of interest has earned itself a reputation as a land of innovation. From penicillin to the black box flight recorder our scientists have come up with the goods. Australian agricultural scientists have made major contributions to that innovation. Just one example and one that is currently significant; is our understanding of pest resistance to pesticides.

Maybe it is due to our often harsh climate and the fact that we are geographically a long way from our markets, but the Australian agricultural industry has also been at the forefront of adoption of these novel concepts and technologies. Whatever the external influences, in the half century since 1960 the adoption and success of minimum tillage, for example, has revolutionised farming in this country.

During that time it has been the efforts of the people attending this conference, and their predecessors, who have made adoption, happen. Great research leading to new understandings and techniques are nothing until they are adopted. We make adoption happen. So this year's theme 'Share knowledge – accelerate adoption' is a very apposite motto for our profession.

The speakers available to you over these two days provide insights on changing world markets, water use efficiency in a harsh land, robotics, as well as the latest developments in varieties, resistance, nutrition and more. I encourage you to take all you can from the program and then go forth and accelerate adoption.

Thanks very much as always to the team who have put the program together and to Matt McCarthy and ORM for facilitating this.

***Mark Pedlar,** Chairman - Adelaide GRDC Adviser Update Planning Committee.*

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*** Networking time - refreshments - AGT**

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SOUTH AUSTRALIA

Share knowledge - accelerate adoption

Adelaide Convention Centre

Tuesday 25th February – Day 1

8.55am	**Welcome**	***Keith Pengilley,*** *GRDC Southern Panel and* ***Mark Pedlar,*** *Planning Committee Chairman*
9.10am	**Strategies and tactics to extend whole farm water use efficiency** - P13	***James Hunt,*** *CSIRO*
9.50am	**Retaining and developing pesticide options for you and your clients** - P27	***Ken Young,*** *GRDC*
10.10am	**Maintaining market access - keeping it clean** - P33	***Tony Russell,*** *GIMAF*
10.30am	***Morning tea***	

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(40 minutes including time for room change) *(R = session to be repeated)*

	Main Hall	Rooms 1-2	Rooms 10-11	Rooms 4-5
11.00am	**Barley agronomy and management update (R)** - P39 ***Kenton Porker,*** *SARDI*	**Impact of canola windrow timingand direct heading - getting it right (R)** - P47 ***Maurie Street,*** *Grain Orana Alliance*	**NSS group trials - exploring herbicide and residual impacts on radish and lentils (R)** - P59 ***Chris Davey,*** *YP AG*	**Pulse check - new varieties & disease update (R)** - P65 & 75 ***Mick Lines,*** *SARDI and* ***Jenny Davidson,*** *SARDI*
11.40am	**Impact of canola windrow timing and direct heading - getting it right** - P47 ***Maurie Street,*** *Grain Orana Alliance*	**Barley agronomy and management update** - P39 ***Kenton Porker,*** *SARDI*	**Pulse check - new varieties & disease update** - P65 & 75 ***Mick Lines,*** *SARDI and* ***Jenny Davidson,*** *SARDI*	**Plant growth regulators in broad-acre crops** - P83 ***Tina Acuna,*** *TIA*
12.20pm	**NSS group trials - exploring herbicide and residual impacts on radish and lentils** - P59 ***Chris Davey,*** *YP AG*	**Commercial corner (R)** ***The latest services and products from the commercial sector***	**Modernisation of China's food industry and what it means to the Australian grains industry** - P89 ***Stephen Radeski,*** *ANZ*	**Sclerotinia and Blackleg of canola - maintaining the vigilance (R)** - P91 ***Steve Marcroft,*** *Marcroft Grains Pathology*

1.00pm ***Lunch***

CONCURRENT SESSIONS

(40 minutes including time for room change) *(R = session to be repeated)*

	Main Hall	Rooms 1-2	Rooms 10-11	Rooms 4-5
2.00pm	**Sclerotinia and Blackleg of canola - maintaining the vigilance** - P91 ***Steve Marcroft,*** *Marcroft Grains Pathology*	**Latest developments in herbicide management research (R)** - P97 ***Chris Preston,*** *University of Adelaide*	**Slug management practices - what is working? (R)** - P103 ***Jon Midwood,*** *Southern Farming Systems*	**Maximising the nitrogen benefits of rhizobial inoculation (R)** - P109 ***Maarten Ryder,*** *University of Adelaide*
2.40pm	**Is social media working for you? (R)** - P115 & 119 ***Pru Cook,*** *DEPI Vic and* ***Emma Leonard,*** *AgriKnowHow*	**Maximising the nitrogen benefits of rhizobial inoculation** - P109 ***Maarten Ryder,*** *University of Adelaide*	**Canola varieties & retained seed study Reviewing canola establishment essentials (R)** - P123 & 127 ***Trent Potter,*** *Yeruga Crop Research and* ***Andrew Ware,*** *SARDI*	**Slug management practices - what is working?** - P103 ***Jon Midwood,*** *Southern Farming Systems*
3.20pm	**Latest developments in herbicide management research** - P97 ***Chris Preston,*** *University of Adelaide*	**Commercial corner** ***The latest services and products from the commercial sector***	**Is social media working for you?** - P115 &119 ***Pru Cook,*** *DEPI Vic and* ***Emma Leonard,*** *AgriKnowHow*	**Canola varieties & retained seed study Reviewing canola establishment essentials** - P123 & 127 ***Trent Potter,*** *Yeruga Crop Research and* ***Andrew Ware,*** *SARDI*

4.00pm ***Afternoon tea***

4.30pm ***Students at work*** - P135

4.50pm **The competitive position of Australian grain in SE Asian markets – five years after deregulation** - P139 — ***Dr Soon-Bin Neoh,*** *Soon Soon Group, Malaysia*

5.35pm **Close and evaluation**

5.45pm ***Drinks*** *(compliments of AGT)*

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Wednesday 26th February – Day 2

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(40 minutes including time for room change)   (R = session to be repeated)

	Main Hall	Rooms 1-2	Rooms 10-11	Rooms 4-5
9.00am	**Barley varieties - 2014 best and fairest (R)** - P191 ***Jason Eglinton,*** *University of Adelaide*	**New aspects on potassium nutrition (R)** - P199 ***Rob Norton,*** *IPNI*	**Spots, blots and rots - cereal disease update (R)** - P205 ***Hugh Wallwork,*** *SARDI and* ***Marg Evans,*** *SARDI*	**Wheat variety review (R)** - P209 ***Rob Wheeler,*** *SARDI*
9.40am	**Managing stacked resistance in wild radish (R)** - P217 ***Grant Thompson,*** *Crop Circle Consulting*	**Barley varieties - 2014 best and fairest** - P191 ***Jason Eglinton,*** *University of Adelaide*	**New aspects on potassium nutrition** - P199 ***Rob Norton,*** *IPNI*	**Spots, blots and rots - cereal disease update** - P205 ***Hugh Wallwork,*** *SARDI and* ***Marg Evans,*** *SARDI*
10.20pm	***Morning tea***			
10.50am	**Wheat variety review** - P209 ***Rob Wheeler,*** *SARDI*	**Managing stacked resistance in wild radish** - P217 ***Grant Thompson,*** *Crop Circle Consulting*	**Soil moisture probes and Yield Prophet®- how do they assist real decision making? (R)** - P229 ***Harm van Rees,*** *Cropfacts*	**Bio pesticides - fresh hope for future options (R)** - P237 ***Gavin Ash,*** *Charles Sturt University*

CONCURRENT SESSIONS

(40 minutes including time for room change) *(R = session to be repeated)*

	Main Hall	Rooms 1-2	Rooms 10-11	Rooms 4-5
11.30am	**Opportunities with liquid systems (R)** - P241 & 245 ***Peter Burgess,*** *Liquid Systems and* ***Alan McKay,*** *SARDI*	**Soil moisture probes and Yield Prophet®- how do they assist real decision making?** - P229 ***Harm van Rees,*** *Cropfacts*	**Improving seasonal forecasts** - P251 ***Darren Ray,*** *Bureau of Meteorology*	**Embracing opportunities and challenges with soil amelioration (R)** - P253 & 259 ***Dave Davenport,*** *SARDI and* ***Roger Groocock,*** *Groocock Soil Improvement*
12.10pm	**Embracing opportunities and challenges with soil amelioration** - P253 & 259 ***Dave Davenport,*** *SARDI and* ***Roger Groocock,*** *Groocock Soil Improvement*	**Opportunities with liquid systems** - P241 & 245 ***Peter Burgess,*** *Liquid Systems and* ***Alan McKay,*** *SARDI*	**Bio pesticides - fresh hope for future options** - P237 ***Gavin Ash,*** *Charles Sturt University*	**Snail control update** - P263 ***Greg Baker,*** *SARDI*

12.50pm ***Lunch***

1.40pm **Robotics and intelligent systems for broad acre agriculture** - P271 — ***Salah Sukkarieh,*** *University of Sydney*

2.20pm **Helping your clients build their emotional and personal resilience** - P275 — ***Dennis Hoiberg,*** *Lessons Learnt Consulting*

3.00pm **Close and evaluation**

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25th & 26th February	**Adelaide SA**	Adelaide Convention Centre

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Friday 7th February	**Lake Bolac VIC**	Lake Bolac Hall
Thursday 13th February	**Corowa NSW**	Corowa RSL Club
Thursday 27th February	**Crystal Brook SA**	Crystal Brook Football Club
Wednesday 12th March	**Wallendbeen NSW**	Wallendbeen Memorial Hall
Thursday 3rd April	**Bridgewater VIC**	Bridgewater Hall
Wednesday 23rd July	**Speed VIC**	
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Wednesday 27th August	**Naracoorte SA**	

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Tuesday 12th August	**Launceston TAS**
Thursday 14th August	**Wagga Wagga NSW**
Thursday 13th November	**Adelaide SA**

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Wednesday 2nd April	**Naracoorte SA**
Friday 15th August	**Southern NSW**
Tuesday 9th September	**North East Victoria**
Wednesday 10th September	**Horsham VIC**
Thursday 2nd October	**Central West NSW**

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Strategies and tactics to extend whole farm water use efficiency - sow on time or early!

James Hunt[1], John Kirkegaard[1], Julianne Lilley[1], Ben Trevaskis[1], Susie Sprague[1], Tony Swan[1], Brad Rheinheimer[1], Mick Faulkner[2], Jeff Braun[2], Dannielle McMillan[3], Alison Frischke[3], Paul Breust[4], and Tony Pratt[4],

[1]CSIRO Sustainable Agriculture Flagship;[2]Agrilink Agricultural Consultants; [3]BCG; [4]FarmLink Research

GRDC project codes: CSP00178, CSP00160, FarmLink Research & CSIRO stubble initiative project number TBA

Keywords

early sowing, slow maturing wheat, winter wheat, time of sowing, frost

Take home messages

- **Maximise wheat WUE by ensuring as much crop flowers during the optimal period as possible – sow on time or early!**
- **Early sown, slow maturing varieties (winter and spring) yield as well as or better than faster maturing varieties sown later – but varieties for most of SA are very limited**
- **Including an early sown variety in a cropping program can greatly increase whole-farm yield**

Introduction

The dry autumn and frosty spring of 2013 continues the pattern of the last 17 years, and is likely to continue into the future (Cai *et al.* 2012). Getting wheat to flower during the optimal period in a given environment is a huge driver of yield and water-use efficiency, particularly with the recent pattern of late frosts, early heat and dry autumns making this very difficult to achieve. The majority of current wheat varieties need to be sown in the first half of May in order to flower during the optimal period for yield in most environments, which unfortunately coincides with the period of recent rainfall decline.

Growers wishing to maximise farm water-use efficiency need to adopt strategies that will allow them to get as much of their wheat crop as possible flowering during the optimal period in their environment. This means having the varieties, rotations, equipment and level of organisation required to take advantage of any sowing opportunity that arises from late summer onward. This article reports results from several experiments conducted across southern Australia and farmer experience investigating the potential for earlier sowing to increase wheat yields in the face of autumn rainfall decline.

Optimal flowering periods

Every production environment has an optimal period in which wheat crops need to flower in order for yield and water-use efficiency to be maximised (Figure 1). This period is defined by an optimal balance between temperature, radiation and water availability, and also decreasing frost risk and increasing heat risk. Optimal flowering periods vary for different locations e.g. the optimal flowering period for western NSW is early to mid September, whilst in the tablelands around Canberra it is the start of November. Growers and advisers should have a firm understanding of the optimal flowering period in their environment, and how to achieve it from different sowing dates with different varieties.

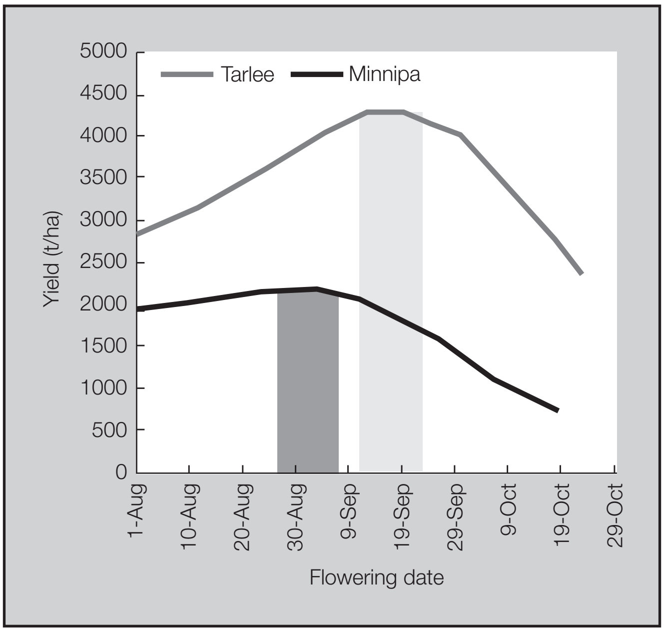

Figure 1. The relationship between flowering time and yield at Minnipa and Tarlee – optimal flowering periods are highlighted by light and dark grey boxes. Curves are derived from APSIM from 120 years of climate data and with a yield reduction for frost and extreme heat events. Optimal flowering periods are late August-early September at Minnipa, and mid September at Tarlee.

The key challenge for growers wanting to maximise whole-farm yield and WUE is to have as much of their wheat crop as possible flowering during the optimal period. This has become increasingly difficult for three reasons;

1. Autumn rainfall has declined significantly in the last 17 years, most likely as a direct consequence of anthropogenic climate change.
2. Recently released varieties for most environments have a very narrow range of maturities and unstable flowering times and only flower during the optimal period if sown between late April and late May.
3. Farm sizes and cropping programs are getting bigger.

For these reasons, growers increasingly need to be able to take advantage of whatever sowing opportunities they can get, and there are three strategies that can be employed in order to ensure as much wheat crop as possible flowers during the optimal period.

1. Sow winter wheats from late February through to April
2. Sow slower maturing spring wheats from mid-April to early May
3. Sow mid-fast wheats from late-April onward; including dry sowing if the break has not arrived by this time.

Currently most growers are comfortable with the third strategy, and this has been the principal adaption to the drying autumns. However, there is great potential for the first two strategies to complement May sowing and further increase farm yield.

Achieving optimal flowering periods – experiments 2013

February-March rainfall has not declined over the past 17 years, and in some areas it has increased (Hunt and Kirkegaard 2011). This rain can be used in lieu of the traditional autumn break to establish crops, but winter wheats are required to achieve this. Winter wheats have a vernalisation or cold requirement which means they will not develop beyond tillering until they have been exposed to

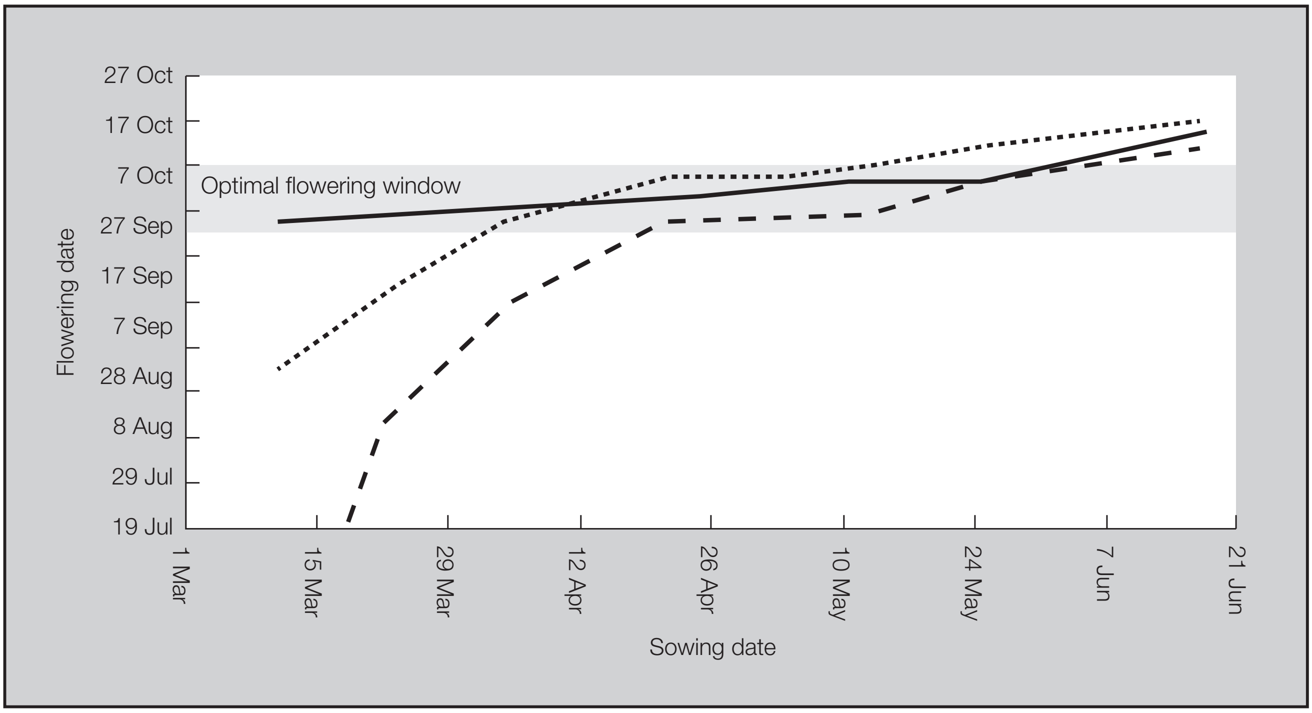

Figure 2. Flowering date of three wheat cultivars from sowings between March and June at Wagga Wagga in 2006 (GRDC, 2011). EGA Wedgetail⁽ᵖ⁾ (——) is a winter wheat with a moderate photoperiod requirement, EGA Eaglehawk⁽ᵖ⁾ (····) is a very slow maturing spring wheat with a strong photoperiod requirement and Janz (– –) is a mid-fast spring wheat with a minor photoperiod requirement (adapted from GRDC Southern Region Time of Sowing Fact Sheet using data from Peter Martin, NSW DPI).

a certain duration of low temperatures (~4-18°C). This gives them a very stable flowering date from a broad range of sowing dates (Figure 2). They can even be sown in summer, and not flower until the optimal flowering period in spring. They are often only thought of as 'dual purpose' (grain and graze) varieties, and have been undervalued as grain-only varieties, particularly in drier areas of the country. Unfortunately, Australian breeding programs stopped selecting for milling quality winter wheats early last decade. There are very few cultivars available, particularly for medium-low rainfall zones with alkaline soils (particularly those with boron toxicity). Commercial breeding companies have now resumed selection for winter wheats, and it is likely that they will play a greater role in our future farming systems as modern, adapted varieties are released.

Sowing winter wheats on summer rain

The Curyo district north of Birchip received 50 mm of rain in mid-February 2013. As part of their Grain and Graze II project, BCG took the initiative and planted an experiment (sown 26 February, 2013) which consisted of a range of winter wheat varieties from various sources planted on a chick-pea stubble. The farmer's paddock (Kord⁽ᵖ⁾ wheat sown 18 May) provided the experimental control.

The winter lines emerged successfully and survived one of the hottest and driest autumns on record. When rains finally came at the end of May, they regenerated rapidly and were able to flower during the optimal period for that environment (Table 1). Yields of the highest yielding lines (Table 2) were equivalent to that of the farmer's paddock sown in May (3.6 t/ha), despite most of the winter varieties having been released over a decade ago, and having no adaptation to the Mallee environment (CCN, salt or boron resistance).

Table 1. Growth stage of different varieties assessed on 12 September 2013. Mid-September is the optimal anthesis (flowering) period for wheat in the southern Mallee

Variety	Ungrazed		Grazed	
	Zadoks code	Growth stage	Zadoks code	Growth stage
YW443	46	Booting	39	Flag leaf emerged
Whistler	63	Early anthesis	51	Early heading
Wylahᶲ	61	Early anthesis	64	Mid anthesis
Wedgetailᶲ	66	Mid anthesis	61	Early anthesis
Rosella	60	Early anthesis	51	Early heading
Revenueᶲ	39	Flag leaf emerged	33	three nodes on main stem
CSIROW8A	53	Early heading	51	Early heading
CSIROW7A	67	Late anthesis	63	Early anthesis

Table 2. Ungrazed grain yield and quality of the winter wheat varieties in the BCG experiment planted at Curyo in 2013

Variety	Grain yield (t/ha)	Protein (%)	Screenings (%)	Test weight (kg/hl)
CSIROW7A	2.7	13.7	1.9	80
CSIROW8A	2.4	13.3	4.3	80
Revenueᶲ	3.4	11.5	4.6	76
Rosella	3.3	12.2	2.7	81
Wedgetailᶲ	2.8	12.4	2.5	77
Whistler	3.0	11.8	4.3	79
Wylahᶲ	2.8	13.1	2.6	76
YW443	1.7	15.4	3.7	74
P-value	*<0.001*	*<0.001*	*<0.001*	*<0.001*
LSD (P=0.05)	*0.3*	*0.9*	*1.2*	*3*
CV%	*6.5*	*4.6*	*24.1*	*2.3*

All lines produced useful amounts of forage for early grazing (0.2-0.5 t/ha), however grazing reduced yield across all varieties by an average of 0.3 t/ha (main effect P<0.001, LSD (p=0.05) = 0.1). See BCG 2013 Season Research Results for more details of this trial.

Whilst this experiment really pushes the boundaries of what is possible with winter wheats, yield of winter wheats is probably maximised if sown from early April onward. Temperatures are too hot during March in this environment for wheat to use water efficiently, and sowing this early is only an

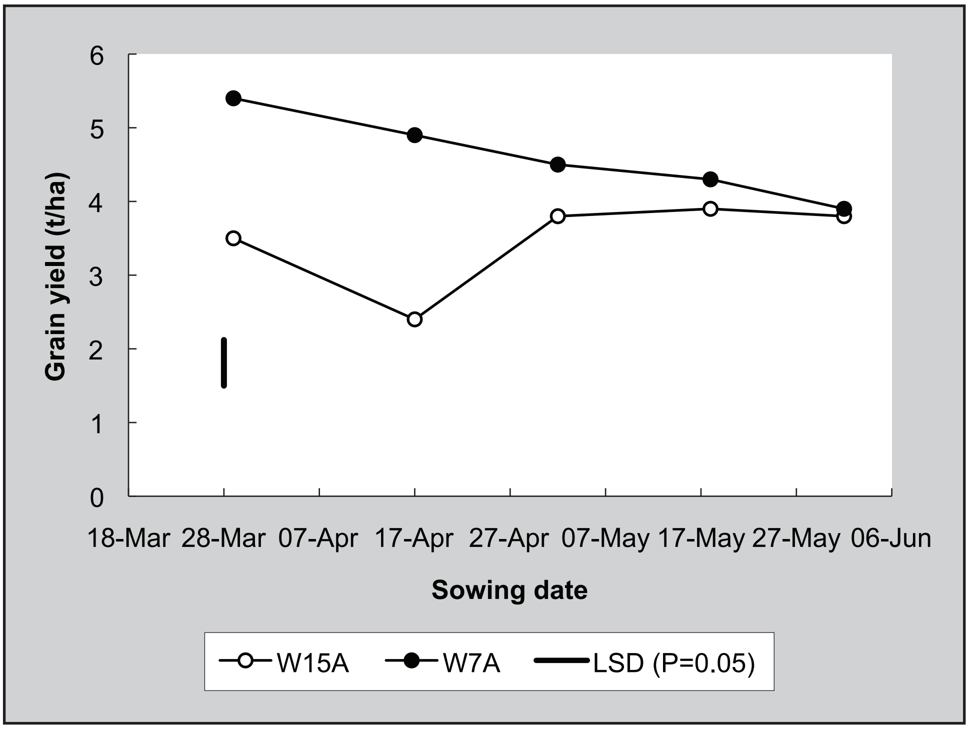

Figure 3. Grain yields of near-isogenic lines at different times of sowing in the experiment at Tarlee. W15A is a fast maturing spring wheat (e.g. Mace⁽ᴰ, Cobra⁽ᴰ) and W7A is a photoperiod insensitive winter wheat (e.g. Wylah⁽ᴰ, Osprey).

advantage if it is intended that crops be grazed, or the break ends up being very late.

This experiment really shows the possibilities which winter wheats could afford our modern farming systems, provided breeding companies could release modern, adapted lines. The south east of SA is lucky to have well adapted winter varieties available (MacKellar, Revenue⁽ᴰ, Manning⁽ᴰ). The rest of SA is not so lucky.

Early sowing in the Mid-North

As part of CSIRO's GRDC funded early sowing and dual purpose cropping projects, Agrilink planted an experiment at the Mid North High Rainfall field day site investigating the potential for early sowing in that environment. Included in the experiment were a set of lines developed by CSIRO that are 97% genetically identical and vary only in their major maturity genes. These are referred to as 'near isogenic lines' (NILs), and are a powerful tool for identifying important maturity genes for adaptation in different environments. A description of the NILs of interest, used in this experiment are given below;

W7A - photoperiod insensitive winter wheat (e.g. Wylah⁽ᴰ, Osprey)

W15A - photoperiod insensitive spring wheat (e.g. Mace⁽ᴰ, Cobra⁽ᴰ)

The experiment consisted of five times of sowing, and in addition to the NILs there were also 'best bet' commercial varieties of different maturities. Picking slow maturing varieties in SA is difficult, because they have not been selected for in SA breeding programs. Consequently, the varieties used are poorly adapted to SA conditions, particularly with regard to boron tolerance.

The first time of sowing on 28 March was watered up with overhead irrigation, and emergence was patchy. All other times of sowing were either watered up with small amounts of drip irrigation, or natural rainfall. All varieties were defoliated a number of times with a ride-on mower from Z13 until prior to Z30 to simulate heavy rotational grazing.

Results from the experiment can be divided into two sections – the theoretical, and the practical. The yield of the NILs proves the theory established in the GRDC WUE initiative (Hunt *et al.* 2013) that slow maturing varieties sown early yield more than mid-fast varieties sown later (Figure 3). They do this by growing deeper roots, reducing evaporation and trading water for dry matter more efficiently. The PPD insensitive winter wheat W7A sown in late March and early April out yields the spring wheat W15A sown at its optimum time in the middle of May by 1.6 t/ha. Sown in May there is no difference between the two.

Whilst this sort of result has been frequently observed with commercial varieties in SNSW, which is lucky enough to have well adapted winter and slow maturing spring varieties (see experiments and case studies below), the same cannot be said for SA (with the exception of the south east). Bolac⦶ (photoperiod sensitive spring wheat) was chosen as the 'best bet' slow maturing commercial variety, and sown early it was no match for Mace⦶ sown in its optimal window in the middle of May (Figure 4). As the NILs demonstrate, this is most likely due to Bolac⦶'s poor adaptation to SA conditions, particularly boron. Even at the 16 April sowing (start of Bolac's optimal sowing window), grazing Mace⦶ to delay its maturity allowed it to out-yield Bolac⦶. This indicates that until adapted slow maturing varieties are available for the SA northern agricultural region, growers who wish to sow early may be better off using well adapted fast maturing spring wheats (e.g. Mace⦶) and grazing them to slow their maturity. In other trials at the MNHRZ site, the winter wheat Naparoo⦶ has been the highest yielding cultivar from a mid-April sowing, but pre-harvest shedding makes it difficult to manage in a time of sowing trial like this.

Incidentally, this experiment corroborated the optimal flowering window for Tarlee identified in Figure 1. The highest yields for Mace where achieved in treatments which flowered in mid-September (Figure 5).

Sowing opportunities – take them as they arise

In regions such as southern NSW, which is lucky to have adapted winter wheats and slow maturing spring wheats (Eaglehawk⦶, Bolac⦶, Lancer⦶) available, it has been repeatedly shown that there is a clear yield benefit from planting slower maturing varieties early (Hunt *et al.* 2013). This was again the case in 2013, as demonstrated by a CSIRO and Kalyx trial comparing the grazing potential and grain recovery of winter and spring wheats sown at different times and with different grazing regimes. The experiment was located at Iandra north of Young on the SW slopes of southern NSW (571 mm median annual rainfall with equi-seasonal distribution). The site received 81 mm of rain from 24 February to 1 March 2013, which was followed by 14 mm on 23 March which made for ideal sowing conditions for a winter wheat (Wedgetail⦶) on 26 March. Another 13 mm fell on 29 March, and the crop emerged well and grew rapidly.

Like most of SE Australia, April was very dry and no further significant rain fell until mid May. Bolac⦶ was planted in its ideal window on 23 April, but into marginal seed-bed moisture, and only 30% of the crop emerged at this time. Gregory⦶ was sown dry on 8 May, and it and the remaining Bolac⦶ only emerged following 8 mm rain on 14 May. Winter was wet, but spring was dry, frosty and hot and the site received 280 mm for the growing season. The site was located on a hill and so largely avoided the black frost of 18 October which devastated crops in the region.

The yields very clearly show the benefit of using slower maturing wheats (winter and slow maturing spring) to take advantage of any establishment opportunity that arises early in the season (Table 3). Wedgetail⦶ and Bolac⦶ both had a 0.6-0.9 t/ha yield advantage over main season Gregory⦶.

Needless to say, the Wedgetail⦶ also provided significantly more forage (2.6 t/ha) than both the spring wheats (0.8 t/ha for Bolac⦶ and 0.4 for Gregory⦶), however grazing (single cut at Z30) reduced yield. This (and the BCG data above) debunks a common misconception that winter wheats are only dual purpose varieties and have to be grazed in order to manage their canopy and achieve good yields. Winter wheats can be highly flexible grain-only varieties in their own right, and a very important tool for managing climate variability.

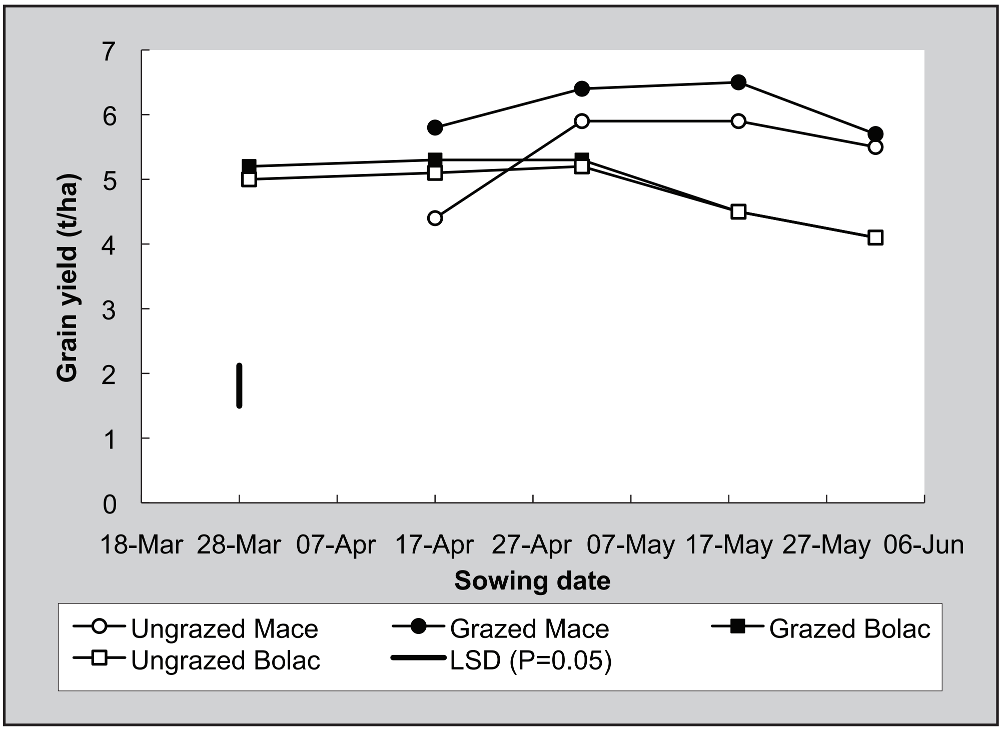

Figure 4. Grain yields of Mace⁽ᵖ⁾ and Bolac⁽ᵖ⁾ grazed and ungrazed at different times of sowing in the experiment at Tarlee. Bolac⁽ᵖ⁾ is a slow maturing spring wheat with excellent adaption to SW Victoria and S NSW.

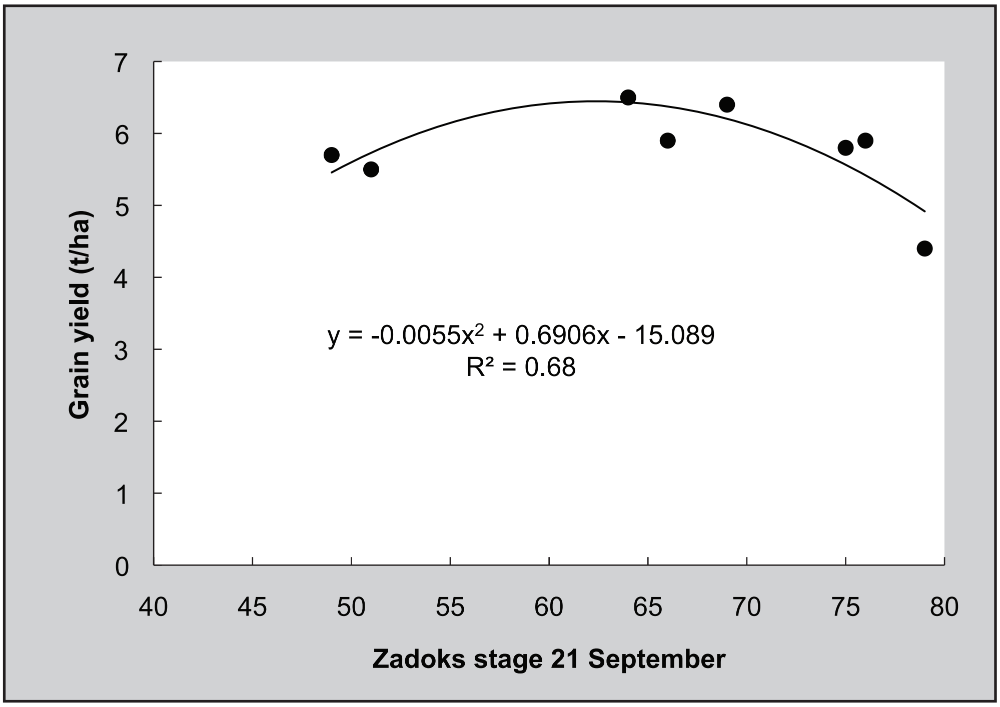

Figure 5. The relationship between Zadoks stage assessed on 21 September 2013 and grain yield in all Mace⁽ᵖ⁾ treatments in the experiment at Tarlee.

Table 3. Crop yields from four treatments at the CSIRO and Kalyx experiment at Iandra, NSW comparing grazing potential and grain recovery of winter and spring wheats sown at different times and with different grazing regimes

Variety and sowing date	Yield (t/ha)	Standard error
Wedgetail$^{\phi}$ - sown 26 March 2013		
Uncut	4.7	0.1
Z30 hard defoliation	4.4	0.2
Bolac$^{\phi}$ - sown 23 April (30% emergence, remainder emerged following rain mid-May)		
Uncut	5.0	0.2
Z30 hard defoliation	4.9	0.1
Gregory$^{\phi}$ – sown 8 May 2013		
Uncut	4.1	0.2
Z30 hard defoliation	4.0	0.1

Farmer experience in 2013

The early sowing message has been rapidly adopted by farmers and advisers in southern NSW where suitable varieties are available, and the following case studies describe some successes and pitfalls of the approach.

Charlie and Lou Clemson, Ardlethan

The Clemson's farm south of Ardlethan received ~50 mm in a highly localised storm at the end of March. Charlie was understandably wary of the recent run of dry autumns, and not knowing when the next sowing opportunity was coming, decided to start planting wheat. He had Bolac$^{\phi}$ seed from 2012, clean canola stubbles on their home block, and started planting on 4 April and finished by 11 April. Paddocks sown on 4 April emerged very quickly, those sown by 7 April were slower as things dried out, which probably turned out to be a good thing.

The start of April is a critical time for slow maturing spring wheats, as it is then that days just become short enough for the photoperiod sensitivity of slow maturing spring wheats to hold back their development (see how Eaglehawk$^{\phi}$ and Janz development becomes slower at the start of April in Figure 2). That is why winter wheats are required for sowing before ~10 April, as their vernalisation requirement stops them from developing when days are long. The Bolac$^{\phi}$ sown on 4 April was probably exposed to enough day length to speed its development, and it had started flowering on 5 August – a good month before the optimal period in that environment. It suffered 40% frost damage, probably from a frost on 16 August (-1.3°C recorded at West Wyalong AWS), but still averaged ~2.5 t/ha of H2 (Table 4). The Bolac$^{\phi}$ sown 7 April flowered quite a bit later and only suffered ~10% damage, and averaged ~4.2 t/ha of H2. Average Bolac$^{\phi}$ yield across the home farm was 3.7 t/ha.

On another two blocks further west, Bolac$^{\phi}$ sown 12-18 April averaged 3-3.3 t/ha (26% of wheat crop) whilst main season varieties (74% of wheat crop) averaged 2.0 t/ha. Across all three farms, Bolac$^{\phi}$ sown 4 to 18 April averaged 3.5 t/ha whilst main season wheats (Gregory$^{\phi}$, Kord$^{\phi}$) sown 1 May to 7 June averaged 2.1 t/ha. This reflected the results of the CSIRO, FarmLink and NSW DPI experiments showing the yield advantages of slow maturing wheats sown early.

Charlie and Lou were generally pretty pleased with the result, and next year will trial some different

Table 4. Hand harvest yields, frost induced sterility and machine harvest paddock averages for Clemson's Bolac⊕ sown in early April. Numbers in brackets are standard error of the mean – if standard errors overlap then means are unlikely to be significantly different

Sowing date	Hand harvest yield (t/ha)	Frost induced sterility (%)	Paddock average yield (t/ha)
4 April	3.0 (0.4)	44 (10)	2.6
7 April	4.2 (0.2)	10 (2)	4.2
8 April	4.9 (0.5)	9 (3)	4.2

Figure 6. Lou and Charlie Clemson inspecting one of their early sown Bolac⊕ paddocks just prior to starting harvest on 24 October.

slow maturing spring wheats and winter wheats on their farm, and depending on results will look to use winter wheat if they get a sowing opportunity in early April again.

Heidi and David Gooden, Osborne

The Osborne district got a sowing opportunity at the start of April, and Heidi and David replicated over hundreds of hectares on their farm the small-plot experiments that CSIRO, FarmLink and NSW DPI had done in the GRDC water-use efficiency project which demonstrated the yield advantages of early sowing (see GRDC adviser update papers from 2013 for results of these experiments). The strategy fitted well with their sowing operation – they planted Wedgetail⊕ and Eaglehawk⊕ from 12 April,

Table 5. Yield and total frost damage (frost-induced sterility and damaged grains) from hand-harvests (4 x 0.9 m quadrats from each treatment), and paddock averages from header yield monitor at Gooden's farm in 2013. Numbers in brackets are standard error of the mean; if standard errors overlap then means are unlikely to be significantly different

Variety and sowing date	Grain yield (t/ha)		Total frost damage (%)		Paddock average yield and quality (t/ha)
	Hill	Flat	Hill	Flat	
EaglehawkΦ 12 April	6.2 (0.1)	1.7 (0.2)	16 (3)	92 (4)	2.9 (HPS1)
WedgetailΦ 12 April	5.5 (0.3)	-	9 (2)	-	3.5 (AUH2)
BolacΦ 23 April	5.7 (0.2)	3.2 (0.5)	1 (1)	61 (18)	2.9 (FED1)
GregoryΦ 5 May	4.2 (0.2)	-	33 (3)	-	3.5 (APW1)

then canola before switching to BolacΦ and LancerΦ around Anzac day and finishing with GregoryΦ and LincolnΦ in early May. The winter at Osborne was exceptionally favourable, and all crops looked sensational… until the Black Frost of 18 October! Frost damage and yields were largely determined by elevation and position in the landscape. Hand-cuts taken on hills show that the findings from the small plot trials held true; early sown, slow maturing wheats yielded more (Table 5). However, across whole paddocks, frost was huge driver of yield (Figures 7 and 8), and average paddock yields were not that different to each other and GregoryΦ sown later achieved better quality (Table 4).

Whilst GregoryΦ on the hill appears to have sustained more frost damage, the absolute number of first florets which were either sterile or contained damaged grain (5 per head) was similar to EaglehawkΦ on the hill (3 per head), but EaglehawkΦ had 23 spikelets per head whilst GregoryΦ had only 17. So whilst the percentage damage was higher in GregoryΦ, in absolute terms (t/ha) the damage in both varieties was about the same.

The Gooden's are a little trepidatious about trying early sowing with slow maturing varieties again – they are unsure if the high biomass of early sown crops is appropriate for there environment and farming system, and in a frosty year the early sown crops showed no benefit over mid varieties sown later.

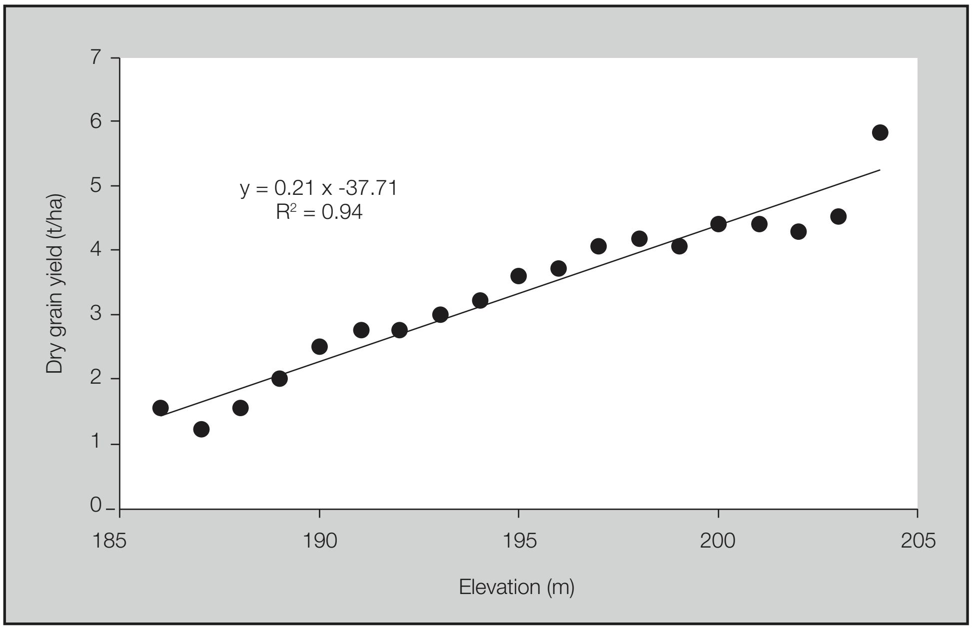

Figure 7. Relationship between elevation and yield for BolacΦ sown 23 April 2013 from Gooden's header yield monitor. Each data point on the graph is an average for each 1 m of elevation and represents thousands of datapoints. Elevation explains 94% of the variation in yield, and yield increased by 0.21 t/ha for every 1 m of elevation.

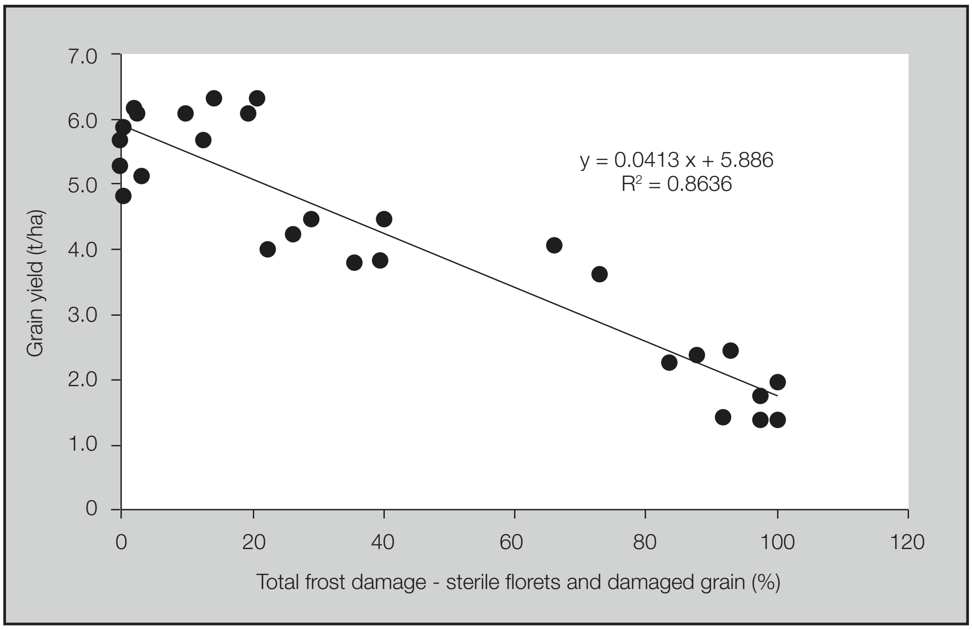

Figure 8. The relationship between frost damage (%) and grain yield from hand harvests at Gooden's farm in 2013.

Figure 9. Heidi, David and Adam Gooden stand in their crop of Eaglehawk⁽ᵇ sown 12 April 2013. This photo was taken at the end of August, the crop ended up being ~1.2 m tall!

A word on frost

The black frost of 18 October 2013 was financially and psychologically devastating to growers across southern NSW and Victoria who were affected. However, one learning from the catastrophe was that delaying sowing (or flowering) is not an effective way of managing risk of late-season frosts. This was starkly illustrated by a grower (who shall remain nameless!) on the south west slopes of NSW who mixed up his seed silos and planted Spitfire⊕ on 22 April and Bolac⊕ in May. This generated a very broad range of flowering dates from 'too early' to 'too late', but all crops were equally affected.

Further evidence of this was provided by a CSIRO experiment in a frost-prone site south of Temora. The experiment was dry-sown on 23 April, but only emerged following rain on 8 May. It included varieties with a broad range of maturities, and flowering extended for a fortnight from 'too early' until 'too late'. Air temperature fell to -3.6°C on the morning of 18 October, and despite all varieties suffering ~60% frost damage, yield still very clearly declined with flowering date (Figure 10). Varieties which flowered on time (or early!) yielded the most.

To have had crops flower after the 18 October frost would have required delaying sowing with main season wheats well into July, which in the majority of years is guaranteed to result in poor yields. Delaying sowing past the optimal date for a given variety is not an effective way of managing frost risk, and historically has probably cost more yield than frost itself.

There are more successful ways to manage frost risk than delaying sowing. Another result from a different experiment at the same Temora site (funded through the GRDC stubble initiative and run in conjunction with FarmLink Research) comparing grazed, burnt and retained stubbles clearly demonstrated the insulating effect of stubble on the soil surface during frost events, and resultant increase in frost damage (Table 6). A similar yield result was observed in 2012, but whilst stubble retained treatments appeared visually to have more frost damage, frost scores showed no significant difference. These trials show the potential of burning stubbles in frost prone sites to reduce the risk of damage.

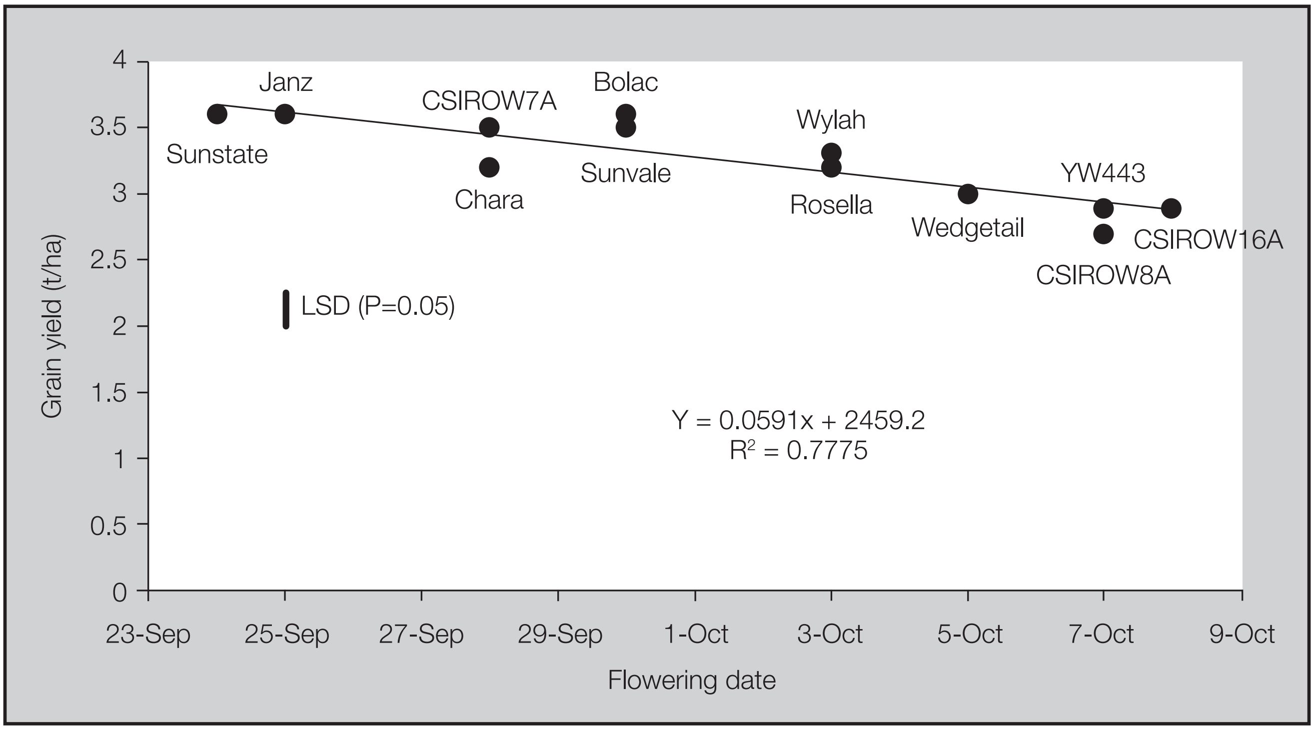

Figure 10. Relationship between flowering time and yield at a CSIRO experiment at Temora in 2013. The optimal flowering period in this environment is the first week of October.

Table 6. Grain yield and frost damage for different stubble treatments applied prior to sowing at the FarmLink and CSIRO stubble initiative site at Temora

Treatment	2013 wheat yield (t/ha)		2013 canola yield (t/ha)		2012 wheat yield (t/ha)	
	Burn (30% frost damage)	Retain (59% frost damage)	Burn (43% frost damage)	Retain (59% frost damage)	Burn (10% frost damage)	Retain (10% frost damage)
Nil graze	3.3	2.2	1.0	0.7	5.0	4.4
Stubble graze	3.6	3.0	1.1	0.9	4.8	4.8
P value	<0.001		0.014		0.003	
LSD (P<0.05)	0.2		0.1		0.3	

Another observation from the 18 October frost and previous events was the strong effect of elevation (Figure 7). This means that frost is able to be managed spatially, and on the SW slopes, farms zoned according to how frost-prone different regions are, were able to avoid the worst of the damage. Frost sensitive crops are not planted in low lying or frost prone paddocks, and only pasture, hay crops, dual-purpose wheat or barley are grown in these areas.

The last obvious way to manage frost risk is through enterprise diversity. Farms in frost-prone areas should maintain enterprises not exposed to frost risk. These could be off-farm investments, or on farm enterprises, such as livestock or hay.

Putting it into practice

Growers wishing to sow early in 2014 need to get themselves in a position to take advantage of early sowing opportunities should they arise. Early-sown wheat needs weed and disease free paddocks; a double break (e.g. pulse/legume pasture/hay crop followed by a canola crop) is an ideal set-up for early sown wheat, particularly in higher rainfall areas.

Growers also need to have a good idea of what their optimal flowering period is, and how to achieve it from different sowing dates with a range of varieties most suited to their environment. If growers keep 2-3 varieties (one winter and one or

Table 7. Wheat maturity groups, sowing windows to achieve optimal flowering windows and examples of best-bet varieties within groups for SA

Winter wheats (South East SA only)	Slow maturing spring wheat (South East SA only)	Mid maturing spring wheat	Fast maturing spring wheat
Late-February – mid-May	**Mid-April – late-May**	**Depends on district – from mid-April in hotter, drier locations**	**Depends on district – from late-April in hotter, drier locations**
Manning$^{(\phi)}$, Revenue$^{(\phi)}$, MacKellar	Forrest$^{(\phi)}$, Bolac$^{(\phi)}$	Trojan$^{(\phi)}$, Phantom$^{(\phi)}$, Estoc$^{(\phi)}$, Yitpi$^{(\phi)}$	Mace$^{(\phi)}$, Corack$^{(\phi)}$, Scout$^{(\phi)}$, Cobra$^{(\phi)}$, Wyalkatchem$^{(\phi)}$

two spring wheats), they are able take advantage of any sowing opportunity that may arise over a three month period (Table 7). It does require growers to be tactical in how much of each variety they grow in a given year, but the potential yield benefits well outweigh the logistical hassles.

Early sown crops do require different management to later sown crops. In higher rainfall regions *Septoria tritici* is a very serious pathogen of early sown crops, and it is recommended that flutriafol in-furrow and earlier foliar sprays are used when sowing early. Barley yellow dwarf virus (BYDV) can be a threat in all environments, but is particularly important in the South East and Mid North of SA, and it is recommended that seed be treated with imidicloprid, or crops closely monitored for aphid infestation and sprayed accordingly. Manning[Φ] and MacKellar both have resistance to BYDV.

Wheat streak mosaic virus can be a serious threat in the higher rainfall zones, and there is no chemical control for this disease or its insect vector. The slow-maturing spring variety Forrest[Φ] has tolerance to the virus, but is really only suited to mid-April sowing, at which time the risk of the virus affecting crops is greatly reduced. Forrest[Φ] also appears to have a 'glass jaw' – it performs well in favourable seasons, but is not competitive with other slow maturing varieties in dry springs.

If planning to graze crops, higher seeding rates and up-front N will maximise early dry matter production. If crops are not to be grazed, then N fertiliser should be deferred until after Z30 to avoid excessive early growth, and if initial soil N is high sowing rates should be reduced. Yield effects of grazing are variable – sometimes positive and sometimes negative, but the effect is rarely more than 0.5 t/ha if grazed in the safe window (prior to Z30). It is certainly not necessary to graze early sown crops to maximise grain production, but they can offer significant amounts of forage at a time when feed can be scarce, and in some instances (e.g. Mace[Φ] at Tarlee 2013) grazing can increase yield.

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Retaining and developing pesticide options for you and your clients

Ken Young,
Plant Health Technologies, GRDC

GRDC project codes: PHA00012, AKC00005, AKC00006, RRR00003

Keywords

pesticides, minor use, registration

Take home messages

- **Utilise GRDC Regional Cropping Networks.**
- **Timelines for growers new management technologies; crop management 1-3 years, pesticides 3-8 years, genetics >8 years.**
- **Demonstrated stewardship of pesticides is required to maintain and get access to pesticides.**
- **Know where your grain is being marketed and the requirements for that market.**

Introduction

Threats to crops continue to mount through a decreasing armoury of management tools particularly pesticides, introduction of new weeds, pests and diseases and resistance to pesticides. Integrated management will become more than just a mantra but part of core business for growers and advisers. We have already seen this with the adoption of harvest weed seed management techniques to be able to bring weed populations (restraint and non-resistant) under control. In weed management other tools that are being used include crop competition (genetics and agronomy). To manage insects, management tactics such as redefining at thresholds, encouraging beneficial insects and using softer chemistries. With plant diseases continued plant genetics, crop rotation and farm hygiene. However, pesticides will still remain the core management tool. For this to occur it will require investment into new chemistry and also reinvention of older chemistry into new uses such as new target species, crops and or new formulations to reduce phytotoxicity, spray drift or compatibility issues. This investment needs to come both from international and national sources.

Tactics for pest management are under continued pressure due to mutations of pests, chemical resistance, agrichemical supply risk and investment and agricultural chemical legislation (Figure 1)

What is GRDC doing to assist growers in maintaining current pesticides and increase options for pest management?

GRDC is investing into fundamental and applied research on plant genomics, resistance genetics, resistance mechanism, and alternative management tactics (chemical, biological, physical and cultural). This talk focuses on GRDC investment in pesticides.

Australia is a very small part of the global pesticide market (2-4%). This coupled with a first world regulation system means case for return on investment for agrochemical companies can be challenging. The investment into Australia also competes as part of the company's global investment dollar i.e. can a better return be made in India, China and or Brazil?

The Australian pesticide market is a very competitive market with a range of suppliers with different business models. These range from global companies involved in discovery of new chemistry to those companies utilising generic chemistry and providing low cost pesticides at low margins to the growers. Any investment by GRDC needs to consider the impact of this investment on current or future investment by chemical registrants. What GRDC wants is to be able to have an environment where there are good incentives for investment by the suite of companies into the Australian market, and therefore, growers' levies and Commonwealth funds can be used for other areas of need of the grower. It is widely thought that the current pesticide regulation in Australia does not provide enough incentives for the range of investments in pesticides that GRDC and other RDC's would like.

The investment by GRDC into pesticides falls into two broad categories – a) discovery of new actives and or new sources of potential actives and b) generation of data for registration purposes.

GRDC investment into the discovery area is blue sky research and high risk and the majority of these projects are limited to an initial investment looking for a feasibility or proof of concept and presently are focussed on bio pesticides. Projects such as compounds for spider venom, nematodes for snail management, granulo viruses and microbial pesticides. These projects are a long way from commercialisation and fit into the 8-10 years horizon.

The other group of investment is the generation of data for pesticide registration. GRDC has two investment projects – PHA00012 Pathways to registration and AKC00006 Minor Use program, with an investment of $750,000 per annum. For projects to get funding under either of these projects they need to pass similar criteria (Figure 2).

Step 1: A pesticides use pattern is nominated by Regional cropping solution groups, Regional panels or GRDC staff.

Step 2: Do these pesticides all have adequate human toxicology and environmental toxicology? Most actives and pesticide formulations will have human and environmental packages associated with their registration package. However, occasionally a pesticide will come up on the list where the active has not been approved in Australia and unless there is access to the toxicology packages GRDC will not invest in generating this fundamental data. Or the active was approved but is presently under review which requires a revisit to the underlying toxicological information. If actives do not have these packages GRDC is unlikely to invest.

Step 3: Is the pesticide a new compound still under patent or is it now a generic compound?

New compound

3a: What is the range of crops that the registrant is seeking to register in Australia? Is there potential for this pesticide to have broader uses particularly in minor use crops? If so GRDC investment may be warranted.

3b: Do these minor use crops have a range of modes of actions already registered or does the registration of a new MOA provide additional risk management for these crops? If so GRDC investment may be warranted.

3c: Will the registrant co-invest with GRDC to generate the residue and or efficacy data for these minor use crops? Where there is co-investment GRDC is more likely to invest.

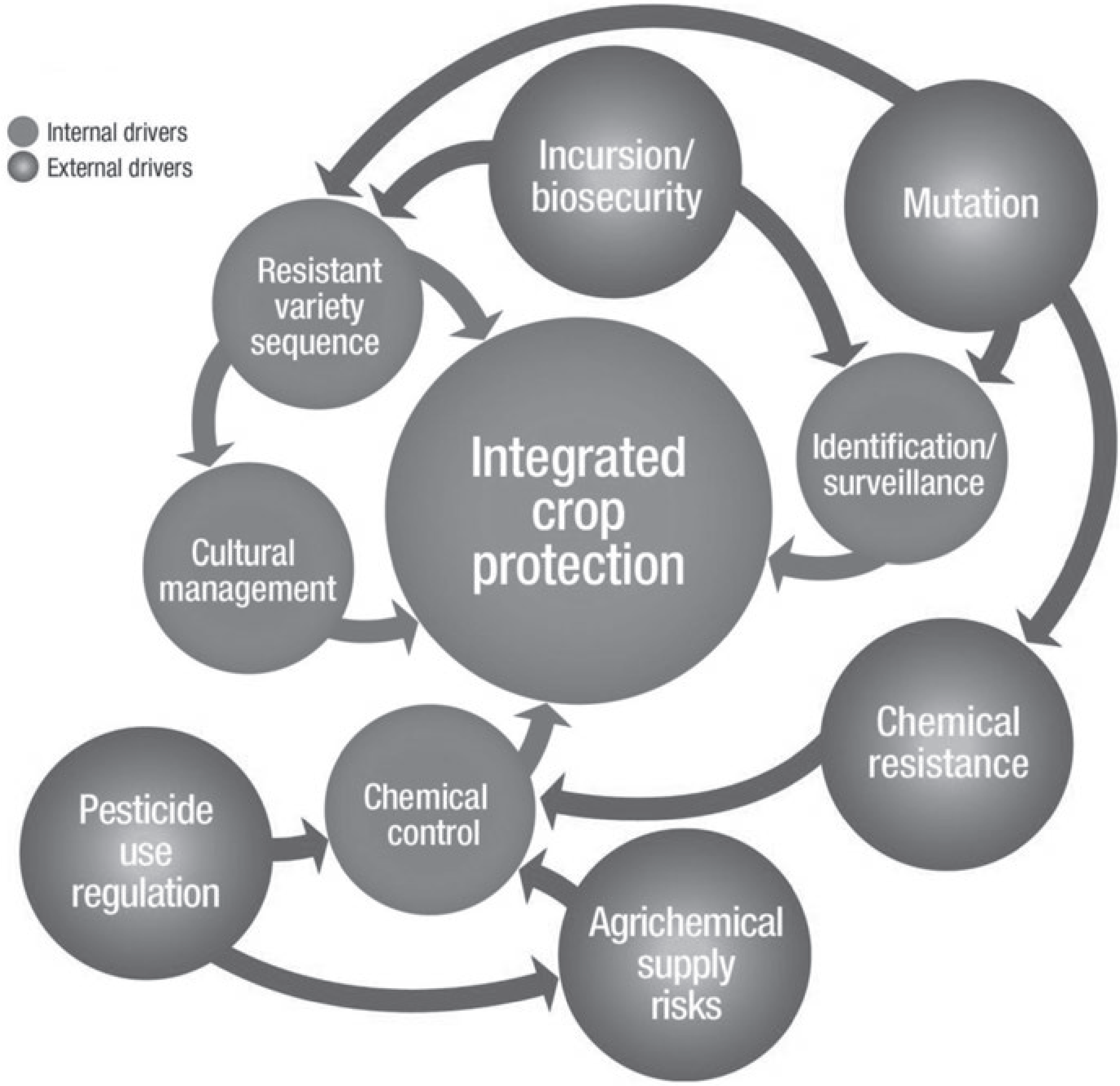
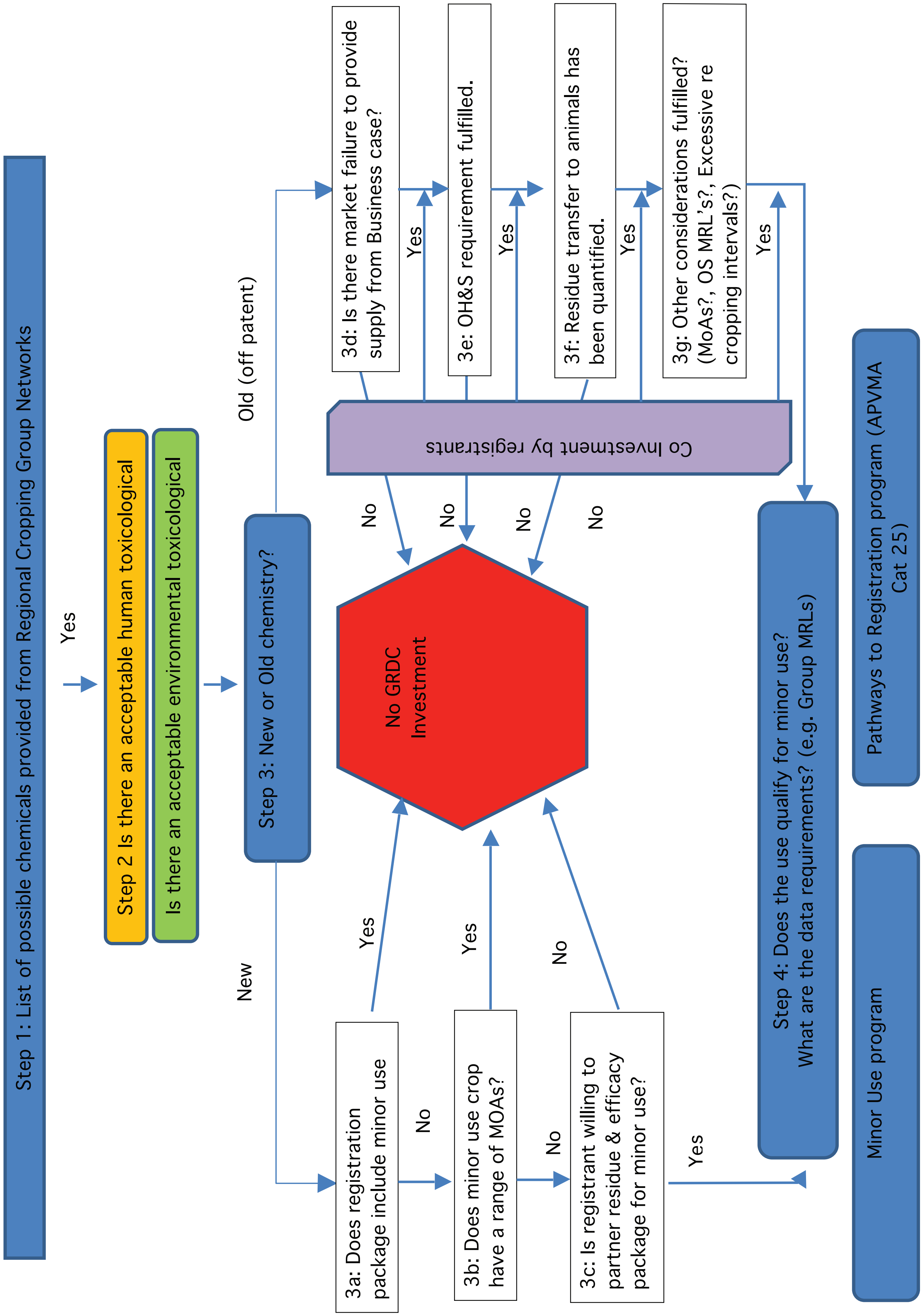


Figure 1. Key external and internal drivers of integrated management approaches for crop pest, weeds and diseases.



Step 1: List of possible chemicals provided from Regional Cropping Group Networks
Yes
Step 2 Is there an acceptable human toxicological
Is there an acceptable environmental toxicological
Step 3: New or Old chemistry?
New
Old (off patent)
3a: Does registration package include minor use
No
3b: Does minor use crop have a range of MOAs?
No
3c: Is registrant willing to partner residue & efficacy package for minor use?
Yes
Yes
Yes
No
No GRDC Investment
3d: Is there market failure to provide supply from Business case?
Yes
3e: OH&S requirement fulfilled.
Yes
3f: Residue transfer to animals has been quantified.
Yes
3g: Other considerations fulfilled? (MoAs?, OS MRL's?, Excessive re cropping intervals?)
Yes
Co Investment by registrants
No
No
No
No
Step 4: Does the use qualify for minor use? What are the data requirements? (e.g. Group MRLs)
Minor Use program
Pathways to Registration program (APVMA Cat 25)

Generic compounds

3d: Has there been market failure to register pesticides for new uses? Here a business case needs to be put together to determine if market failure has occurred and if it has, why there is market failure?

3e: New uses for pesticides can easily trigger the need for the regulator to require an OH&S assessment. This could be due to a formulation change, a different method of application, different rates (if higher) and increased application times. While some of these can be done as desk top studies, others may require the generation of exposure data to determine the risk to operators, mixer handlers and bystanders. The Office of Chemical Safety will rely on standard scenarios, which are conservative, where there is no data for the proposed use. If field studies are required to assess the risk of the new use, these are expensive studies and GRDC is unlikely to invest.

3f: If the new use is on crops which can be grazed even at times of crop failure, the APVMA may require an animal transfer data. This is to see if any pesticide residues in the crop, straw, hay, etc. can be transferred into animal products such as meat, milk, or eggs. If this data needs to be generated, GRDC is unlikely to invest.

3g: Other considerations before deciding whether to invest are; the number of modes of action and resistance status for the proposed use, the change in farming practice required to accommodate new use (e.g. re-cropping interval), the impact of overseas' MRLs, the relative size of the overseas market to the total market, and any requirement for QA packages to manage risk of the new use and the ability for the grains industry to manage.

Step 4: If the flow chart indicates GRDC investment, then whether the data generation is conducted under PHA00012 (Pathways to registration) or AKC00006 (Minor use permits) is determined by a) the APVMA criteria for minor use and b) the difference in data requirements for minor use or full registration.

The investment then is prioritised against other pesticide use patterns and tenders are called to carry out the proposed data generation. Once the data is collected the project teams either submit a registration or permit application to the APVMA or after discussion with chemical companies they may submit the data as part of their registration application.

This process takes between 2 – 3 years from conception through to registration and appearance on labels. While it is understood that growers and advisers are under pressure to manage their plant health issues, implementing new use patterns of pesticides on farm prior to registration review puts not only their crop at risk but potentially all growers' market access for the grain. It also risks the introduction of newer chemistry and re-invention of older chemistries to come to Australia as growers' stewardship of pesticides is undermined.

GRDC will continue to invest into novel management tactics for plant health issue whether these are based around chemicals or not.

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Notes

Maintaining market access - keeping it clean

Tony Russell,
Grains Industry Market Access Forum

Keywords

market access, exports, customer demands

Take home messages

- **Export customers for Australian grains are becoming increasingly discerning about phytosanitary, hygiene and food safety concerns in imported grain and other food products.**
- **It is vital that our industry continues to maintain high standards in meeting customer demands.**
- **GIMAF continues to play an important role in coordinating industry efforts to maintain and improve market access for Australian grains in an impartial manner.**

Background to Grains Industry Market Access Forum (GIMAF)

GIMAF works in conjunction with the Australian government and its agencies to develop and implement international market access plans for the grains, fodder and seeds industries. GIMAF's members are peak industry bodies; the Australia Grain Exporters Association, Australia Fodder Industry Association, Australian Oilseeds Federation, Australian Seeds Federation, Pulse Australia and Grain Producers Australia.

While its core activities are focused on direct marketplace issues that are prioritised by the GIMAF Committee, GIMAF also provides input to the wider trade policy agenda. GIMAF employs a full-time executive manager and works in conjunction with staff and its member bodies and industry stakeholders, contracting additional resources as necessary.

Since establishment in 2011 GIMAF has actively pursued issues through the Department of Agriculture and the Department of Foreign Affairs and Trade (DFAT), providing input on country to country free trade agreements and directly engaging with customer countries.

Key GIMAF achievements in 2012/13

Australia-China canola trade re-opened

Issue: Canola exports to China were halted in 2009 amid concern from the Chinese Government over the risk of importing a strain of blackleg fungus not found in China. Restarting the trade required understanding and agreement on supply chain processes to manage blackleg satisfactorily for both countries.

Action: GIMAF's role was contact, facilitation and coordination, intended to keep the various parties focused on the issue amid competing priorities. GIMAF worked closely with the Australian Oilseeds Federation to seek action from the Department of Agriculture to negotiate diplomatic and scientific solutions with China's biosecurity agency.

GIMAF took an active role in the diplomatic effort, hosting a reception in Beijing during August 2012 at which members of the Australian and Chinese oilseed industries emphasised to government representatives from both countries their strong support for resuming trade. Three Chinese scientists subsequently travelled to Australia's canola producing states and gained a thorough understanding of the Australian industry.

Visits like this are extremely important for scientific and trade relationships; they directly contributed to the success of the subsequent Department of Agriculture mission to Beijing and have led to further visits by Chinese representatives to assist with ongoing understanding and management of blackleg.

Result: A new import protocol was agreed in March 2013 with canola shipments arriving in China by May. GIMAF representatives were in Beijing in July 2013 when the new agreement was formally signed. The new canola protocol is being supported by ongoing research on the management of blackleg. GIMAF believes this work will form a vital component of the grain industry's capability to address trade questions from customer countries as they arise, hopefully avoiding future trade interruptions. *Over 600,000 tonnes of canola has subsequently been shipped to China.*

Barley to Korea improved protocols

Issue: South Korea required mandatory (and costly) screening of barley pre-shipment to manage presence of live vineyard snail (*Cernuella virgata*).

Action: GIMAF coordinated Department of Agriculture biosecurity and trade officials together with GIMAF members to plan reasonable and logical supply chain procedures to meet Korea's phytosanitary requirements. GIMAF prepared an industry management plan that was proposed to Korea by the Department of Agriculture.

Result: The new protocols were accepted and barley shipments are occurring without need for screening.

Iran wheat protocol resolved

Issue: Iran imposed a mandatory pre-shipment fumigation requirement on all wheat imports.

Action: GIMAF sought action as a high priority issue with the Department of Agriculture, which negotiated an on-board fumigation procedure and the removal of Striga sp. from the prohibited weed seed protocol.

Result: Trade continues with cost-effective arrangements for customers and exporters.

Maintaining Market Access for Australian Grains

Export customers for Australian grains are becoming increasingly discerning about phytosanitary, hygiene and food safety concerns in imported grain and other food products. In addition the advances in technology and improvements in sampling and testing regimes in importing countries has placed more pressure on exporters to improve standards and eliminate breaches of MRL's for grain protectants and the presence of quarantined weed seeds, pests or diseases. Some important markets are now instituting regular reviews of protocols applying to the import of major grains. These issues all have an impact on the maintenance of market access and it is vital that our industry continues to maintain high standards in meeting customer demands.

The presentation provides some useful feedback from a market trends survey carried out in 2013 which highlighted that there needs to be an improved coordination of effort between the pre and post farm gate sectors of the industry. Priority issues included:

- Improved whole of supply hygiene required - disconnect between on-farm management, transport and storage and handling providers in how to best manage the export supply chain.
- Insect resistance to existing treatments causing major problems as tighter residue requirements by importing countries restrict usage.

- Resolution as to whether enforceable codes of practice and quality assurance systems (on-farm stewardship programs) or less regulation associated with heightened education of the issues is more appropriate.
- Discussion around the existing MRL's to applied chemical treatments and possible increase in rates to improve efficacy.
- Need for alternative treatments and improved understanding of market concerns and demands along with strategies to support ongoing trade.

GIMAF continues to play an important role in coordinating industry efforts to maintain and improve market access for Australian grains in an impartial manner. GIMAF prioritises issues in the national interest to guide government resources in the negotiation and resolution of market access issues to ensure a strong and viable industry.

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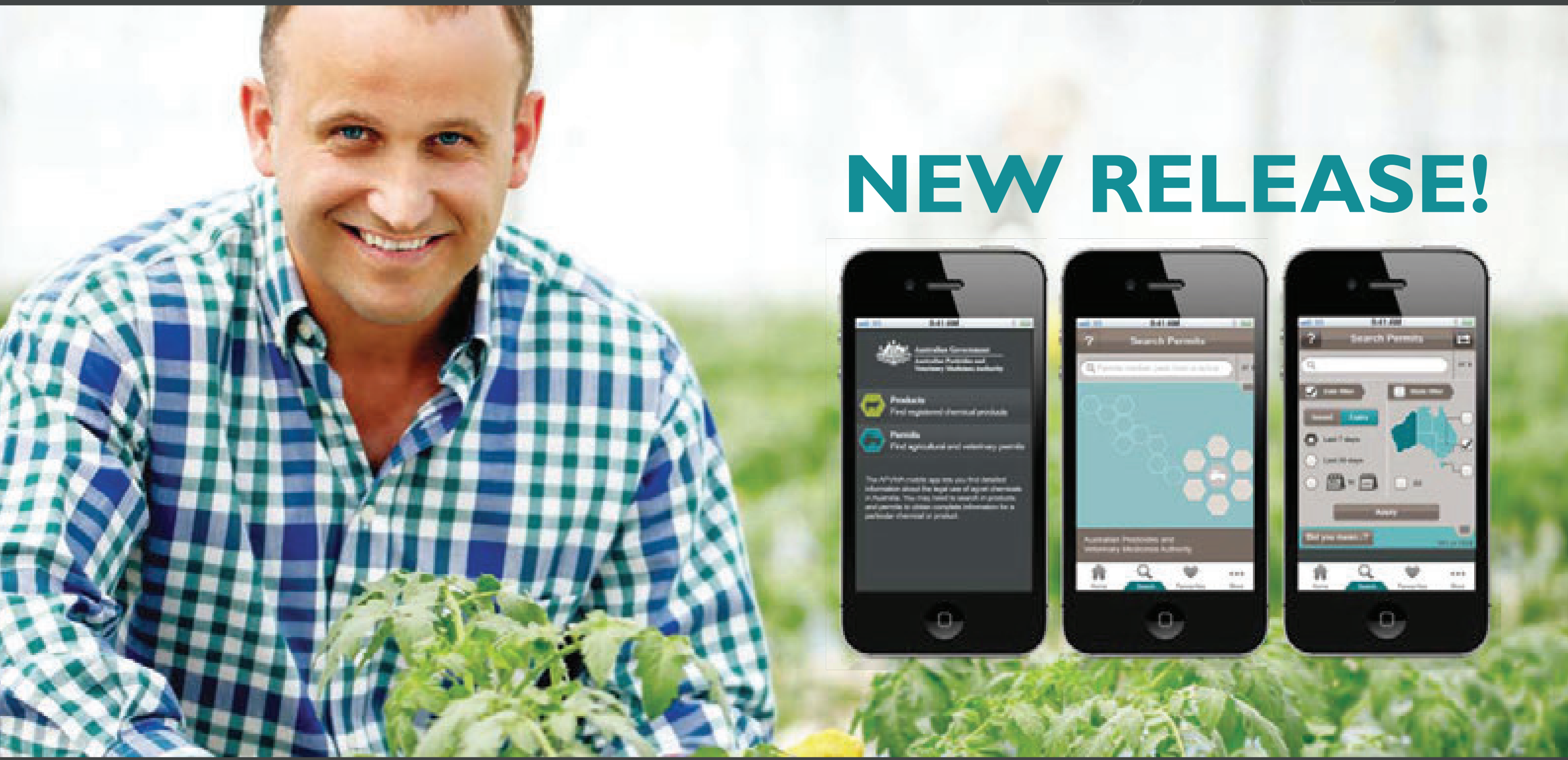
Notes

South Australia

Grains Research UPDATE

Concurrent Sessions

Australian Government
Australian Pesticides and Veterinary Medicines Authority



APVMA permits database goes mobile

The second release of the FREE APVMA mobile app is now available, providing on-the-go access to the APVMA's permits database.

The app provides a radically simpler, intuitive user interface with real-time access to the APVMA's agricultural and veterinary medicines chemical registration and permits databases and is of particular relevance for those reliant on minor use authorisations in the horticultural and minor grains industry.

Chemical users—farmers, vets, householders, industry, chemical manufacturers, environmental managers and researchers—are now able to:

- review product labels
- view off-label authorisations
- search by category, alphabetically, suspended or cancelled products and 'did you mean?' searches
- save searches and email results
- find information on product formulations, active ingredients, withholding periods, pack sizes, pests treated, hosts treated, states where the product is registered and poison schedule information.

To download, search 'APVMA' on the App Store. For more information, visit www.apvma.gov.au.

Available on the App Store

Getting the best from barley – agronomy and management

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GRDC project code: DAN00173

Keywords

barley agronomy, varieties, weed competition, grain protein, nitrogen management

Take home messages

- **Varieties differ in their sensitivity to management practices and should be managed accordingly.**
- **Hindmarsh⊕ and semi dwarf varieties compete poorly with weeds.**
- **More vigorous varieties Fathom⊕ and Maritime⊕ show superior weed competiveness.**
- **Commander⊕ and Buloke⊕ are low protein achievers and benefit from later applications of nitrogen (N).**
- **More N responsive varieties such as Hindmarsh⊕ benefit most from earlier applications of N.**

Introduction

New barley cultivars are evaluated within the NVT system across regions, under a limited range of management practices. The Southern Barley Agronomy Project aims to add value to the NVT system and test the response or sensitivity of varieties to agronomic practices by comparing the yield and quality responses of new varieties, under a range of management practices and environments. This information assists in the development of variety management guidelines and helps to close the yield gap between seasonal potential yield and actual yield through optimal agronomy of the barley variety. Presented below is a snap shot of some of the outcomes resulting from the current project.

Variety interactions with management

Varieties differ in their sensitivity to management practices, and therefore, not all barley varieties can be treated as equal and in some circumstances should be managed differently. Table 1 summarises the frequency in which there have been significant interactions ($p<0.05$) between varieties and a selection of management factors for grain yield and the main quality receival parameters from plot trials conducted across SA from 2008 - 2013. These results suggest that varieties are more likely to differ in their yield and quality response to management factors such as nitrogen rate, sowing date, and harvest date more frequently than seeding rate and sowing depth.

Table 1. The frequency[1] in which barley varieties have differed in their response to a change in management factors from barley agronomy trials conducted during the period 2008-2013

	Nitrogen Rate	Seeding Rate	Sowing Time	Harvest Date	Weed Competition	Sowing Depth
Grain Yield	Often	Rarely	50% Chance	Consistently	Consistently	Often
Retention (%>2.5mm)	50% chance	Occasionally	Often	Rarely	Occasionally	Rarely
Screenings (%<2.2mm)	Often	Rarely	Consistently	Rarely	Occasionally	Rarely
Test Weight (kg/hL)	Rarely	Rarely	Consistently	Consistently	Rarely	Rarely
Protein (%db)	Often	Rarely	Often	Rarely	Rarely	Occasionally
No. trials	16	11	10	8	11	6

1 *Rarely (interaction observed in fewer than 20% of trials), Occasionally (20 – 40% trials), 50% chance (40 – 60% trials), Often (60 – 80% trials) and Consistently (interaction observed in more than 80% of trials).*

Barley variety response to weed competition

When compared to wheat, barley is a vigorous growing crop and is considered to have improved weed competiveness; however there is considerable variation amongst barley varieties for their ability to compete with weeds. Barley is typically sown into paddocks with higher weed burdens and where grass is more prevalent. The increased reliance on grass herbicide chemistry raises concerns about the risk of further developing widespread resistance and it is therefore prudent to implement other strategies such as competitive varieties to help manage grass weeds and maintain the effectiveness of current herbicides.

Trials have been assessing the competitive ability of current barley varieties for their ability to yield in the presence of grass weeds (tolerance) and their ability to suppress the weed seed set. Key variety differences have been identified from trials conducted at Turretfield since 2011 and at Karoonda in 2013. Commercials oats were under sown to simulate a grass weed with the yield of both the oats and barley recorded. The relative varietal responses from a 2013 trial are shown in Figure 1 and are based on the two measures of suppression and tolerance.

HindmarshⒹ and Yarra are short semi dwarf varieties and have consistently shown to be poor competitors with weeds at all sites/seasons, and therefore, are likely to be more reliant on herbicides and other weed control techniques more similar to that of bread wheat. Other varieties that lack vigor early in the growing season such as NavigatorⒹ, GairdnerⒹ, BassⒹ and WimmeraⒹ also have regularly been poor competitors. Whereas, tall and more vigorous varieties such as MaritimeⒹ, FleetⒹ, FathomⒹ and SkipperⒹ have shown superior weed competiveness and can reduce the weed set by more than half that of HindmarshⒹ and still maintain a higher yield.

Pre-harvest weather damage on barley varieties

Rainfall and strong winds around harvest time are not uncommon in Southern Australia. Winds were prevalent in 2013 resulting in widespread reports of awn and head loss in some barley varieties. The ability of current commercial varieties to tolerate these conditions has been assessed in field trials at Turretfield and Moyhall during 2012 and 2013. Up to 24 varieties were harvested at two dates, beginning at physiological maturity and again more than 30 days later after significant rainfall and

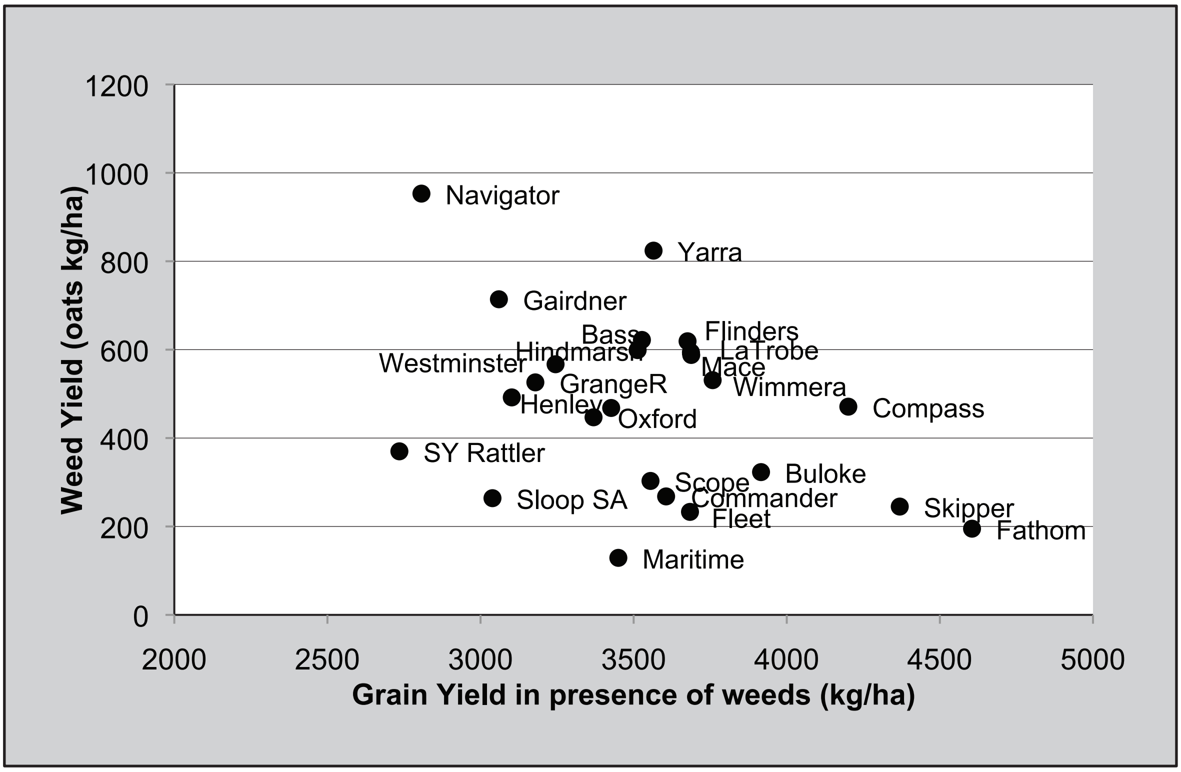

Figure 1. The grain yield of barley varieties in the presence of weeds (oats) plotted against the yield of weeds (oats) at Turretfield 2013. (Grain yield LSD p< 0.05 =445kg/ha, Weed Yield LSD p<0.05= 218kg/ha).

wind events that were conducive to head loss and quality downgrading. Lodging and head loss were measured at each harvest date and physical tests were conducted on grain samples from each plot.

Yield loss from delaying harvest has been most prevalent in Sloop SA$^{\phi}$, a variety known to have poor head retention losing up to 180heads/m^2 in some trials and resulting in grain yield losses greater than 2t/ha between harvest dates (Figure 2). Importantly newer barley releases have not been as susceptible to head loss as Sloop SA$^{\phi}$. Of the newer releases Oxford did not incur significant yield losses from a delay in harvest across all three sites/seasons. GrangeR$^{\phi}$ and Bass$^{\phi}$ also demonstrated good head retention with minimal yield losses. Hindmarsh$^{\phi}$ and LaTrobe$^{\phi}$ have both displayed superior straw strength and reduced lodging compared to other varieties such as Keel, Skipper$^{\phi}$, and Fleet$^{\phi}$ when harvest is delayed. However their improved straw strength has not necessarily translated to improved head retention, with both Hindmarsh$^{\phi}$ and LaTrobe$^{\phi}$ recording large yield losses from a delay in harvest at more than one site/season suggesting they should be harvested early within a program along with other varieties more prone to head loss.

It is important to note factors other than wind conditions can contribute to head loss; disease, plant stress and or changes in environmental conditions coinciding with the development period for a variety (maturity) may influence the severity of head loss. Varieties are harvested as close to

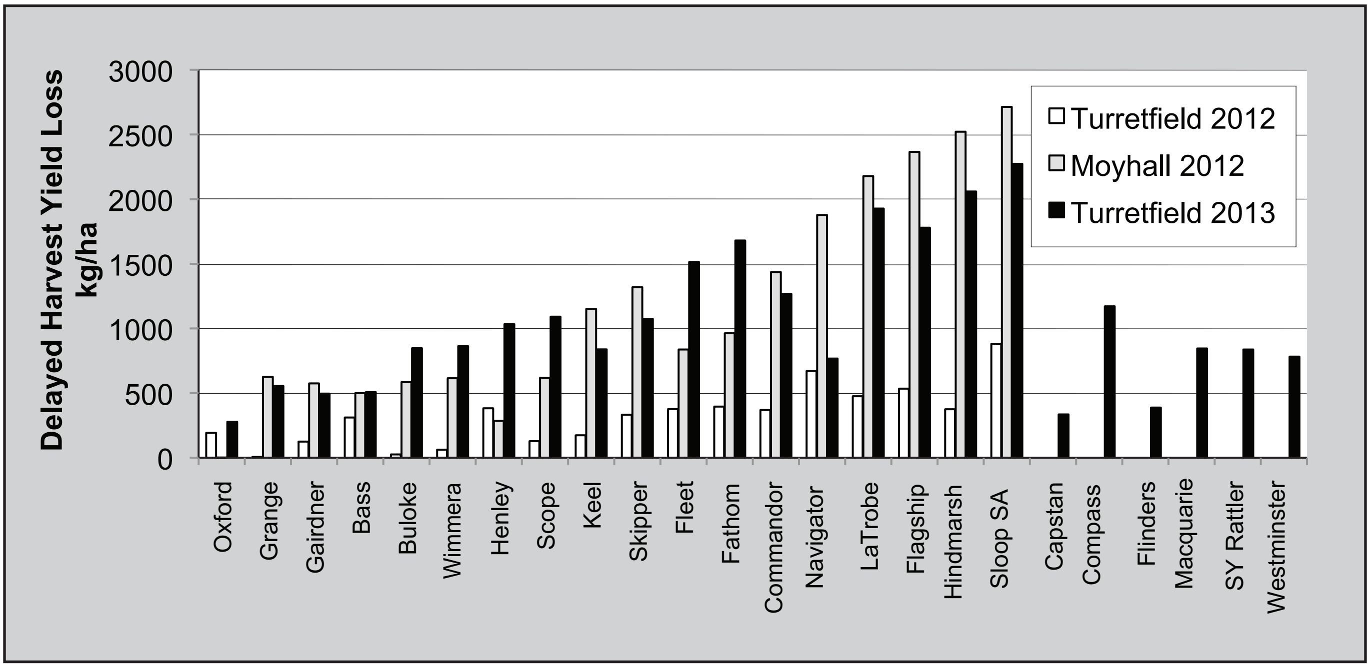

Figure 2. Yield loss (kg/ha) of current barley varieties between early and delayed harvest at Turretfield 2012 (LSD 0.05=225kg/ha), Turretfield 2013 (LSD 0.05= 395kg/ha) and Moyhall 2012 (LSD 0.05 = 450kg/ha) in current barley varieties.

maturity as possible in these trials and plots sprayed with fungicide. Leaf rust and spot form of net blotch infections in commercial paddocks may have contributed to a weakening of the plant structure and resulted in greater head loss than what has been reported here. Barley agronomy fungicide trials have shown a late spray of fungicide to protect against leaf rust significantly reduces lodging and head loss in the varieties that are most susceptible to disease.

Managing grain protein- variety specific responses to nitrogen

Malt barley GTA receival standards require a grain protein concentration (GPC) between 9 – 12% (dry basis) for delivery as Malt1. It is not uncommon for protein of barley to fall below 9% in favourable environmental conditions and low soil fertility. It is often questioned as to whether varieties may differ in their ability to achieve protein targets. Commander⍁ and Buloke⍁ are two varieties with improved yield performance relative to previous malt varieties; however they also show low GPC across SA NVT trials. In commercial production Commander⍁ has been downgraded more frequently for low GPC compared with other varieties. In general a negative correlation exists between grain yield (GY) and GPC (Simmonds et al 1995). It was therefore anticipated that the lower protein being observed in some varieties may be due to yield dilution rather than genetic differences in protein accumulation. Given the large influence of environment and differing yield potentials it is often difficult to characterise a variety as a low or high protein achiever just by using a small set of trials. Monaghan *et al.* (2001) and Oury and Godin (2007) proposed that the deviation from the regression line between grain yield (GY) and GPC from a large series of trials could be used to identify cultivars having either a lower or higher GPC than expected from their given yield level. This deviation was called the grain protein deviation (GPD) and is illustrated in Figure 3.

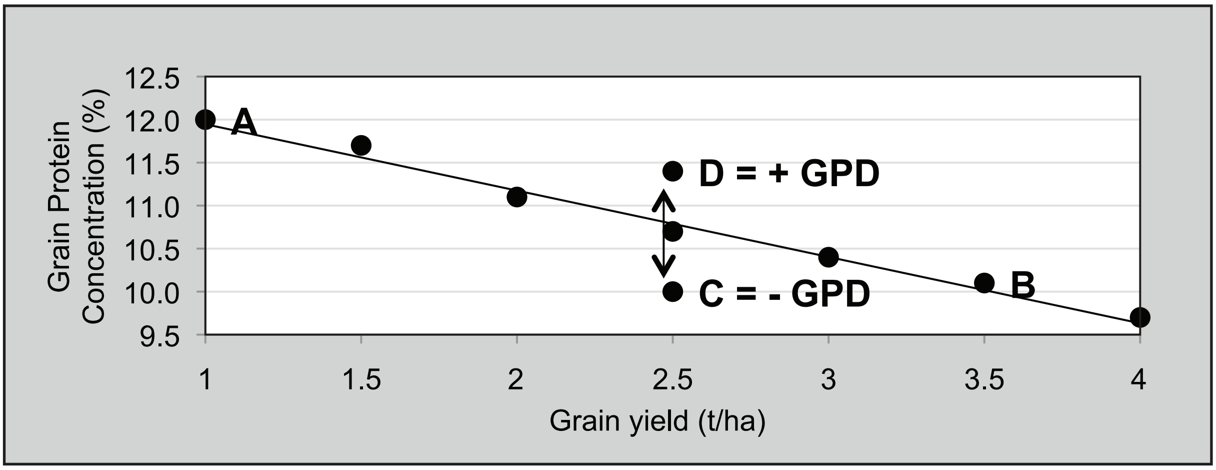

Figure 3. Example relationship between grain yield and grain protein concentration (A to B), with two cultivars having a negative (C) or a positive (D) grain protein deviation.

An exploratory grain protein by grain yield (GY) regression analysis of 56 NVT yield trials from 2010-2012 (SA) suggested that grain protein differences among cultivars, after eliminating the yield influence are significant and there is evidence of genetic control of GPC in current barley varieties. A box plot diagram (Figure 4) exemplifies the distribution of protein deviations from the GPC/GY regression for varieties. The mean values obtained from the 56 environments for deviations away from the GPC/GY regression varied among cultivars from -0.93% in Oxford to +0.71% in Flinders⁽ᵖ⁾. Oxford, Commander⁽ᵖ⁾ (-0.82), Buloke⁽ᵖ⁾ (-0.77), and Scope⁽ᵖ⁾ (-0.6) all were below the regression line and despite variability among trials, Buloke⁽ᵖ⁾ and Commander⁽ᵖ⁾ shared a similar distribution pattern; in that in over 50% of trials, they both achieved a lower GPC for a given yield level (highest frequency negative), and Flinders⁽ᵖ⁾ and Maritime⁽ᵖ⁾ were positive. Most other varieties did not significantly differ from the GY/GPC regression meaning their protein content could be explained by the inverse relationship between GY and GPC as expected (normal).

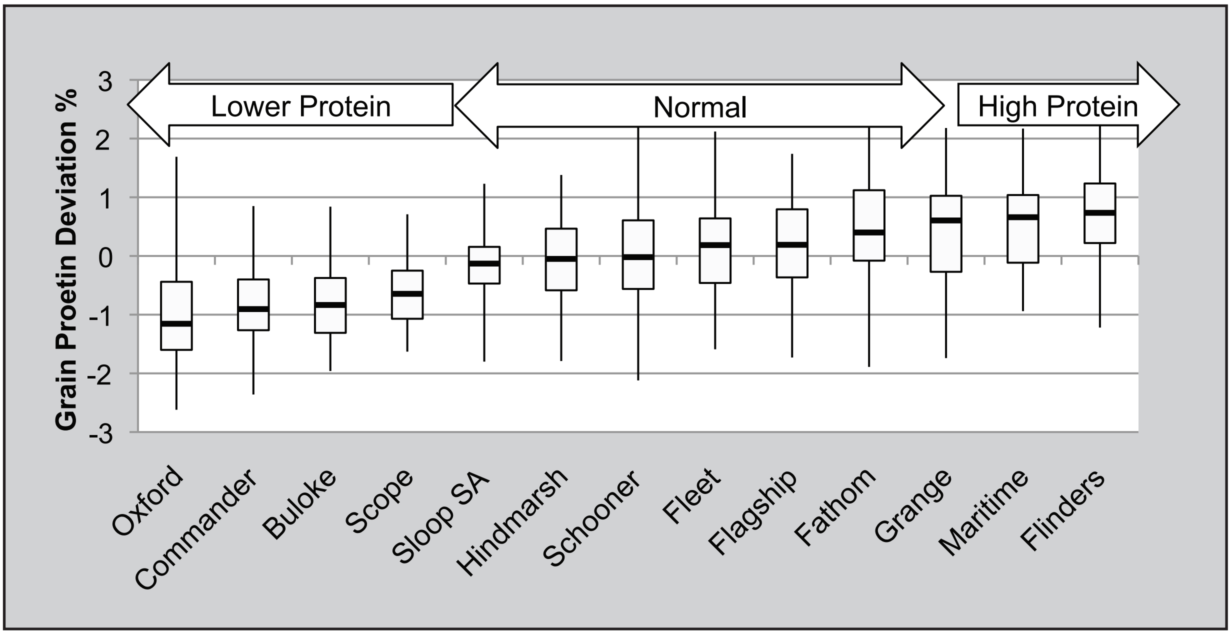

Figure 4. A boxplot diagram of the GPD values obtained in varieties in a total of 56 different environments. . The black, central line in the box represents the median values, the box edges are the 25th and 75th percentile and the whiskers extend to the most extreme points not considered to be outliers.

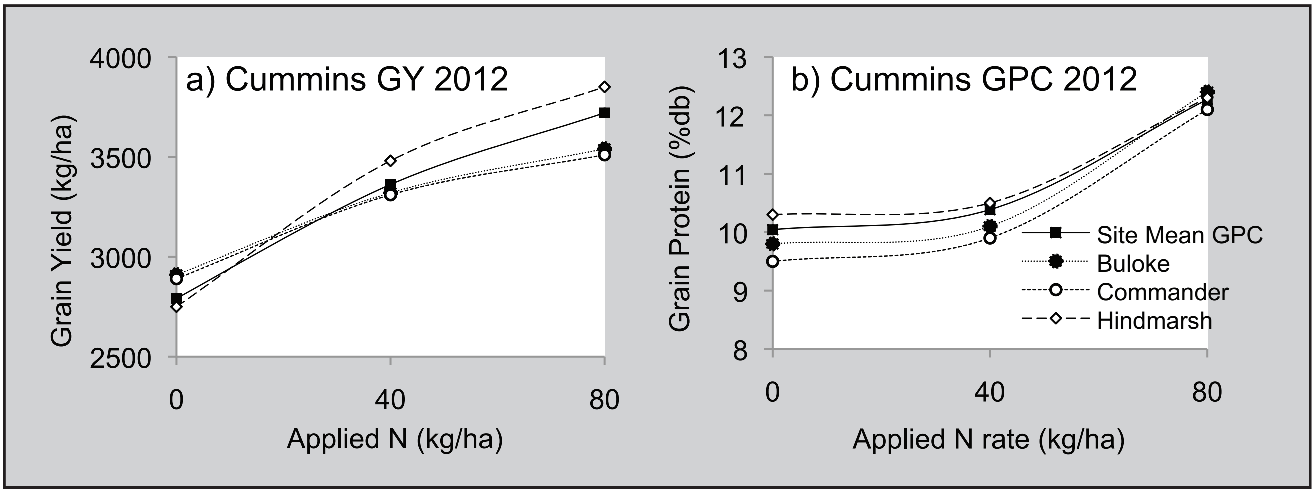

Figure 5. The varietal GY (a) and GPC response (b) to applied N at Cummins 2012. The variety x N treatment interaction was significant for both GPC and GY. The symbols represent varieties Hindmarsh⑪, Buloke⑪, and Commander⑪, the site mean is of all eight varieties included in the trial. LSDs (0.05) for N x Var are 289kg/ha for GY and 0.31 for GPC.

For any given yield level, Oxford, Commander⑪, Buloke⑪, and Scope⑪ are therefore expected to achieve a lower GPC and Maritime⑪, and Flinders⑪, a higher GPC relative to current commercial cultivars. Different N management strategies may be required for some varieties (i.e. Commander⑪ and Flinders⑪) in order to maximise the chance of meeting industry receival standards for grain protein. Varieties inherently low in GPC may be useful in conditions of excessive soil N or in situations where N is applied to maximise yield.

Nitrogen responses

A series of agronomic trials across SA investigated whether barley varieties respond differently to nitrogen (N) application. At N responsive sites, varieties differed in both their yield and protein response to N. The grain yield increase to applied N was greatest in Hindmarsh⑪ relative to Commander⑪ and Buloke⑪. Sites in 2012 and 2013 also found Fathom⑪ and LaTrobe⑪ all expressed N responses similar to Hindmarsh⑪ and were also more responsive to N than Buloke⑪ and Commander⑪, whereas Skipper⑪ and Wimmera⑪ were more responsive only at a higher N supply. The relative GPC responses of cultivars to N indicated Commander⑪ and Buloke⑪ consistently achieved a lower GPC than Hindmarsh⑪ and other varieties at suboptimal N supply despite yields being similar between varieties. An example of this relationship is expressed below (Figure 5) from a trial at Cummins in 2012.

Averaged across all N responsive sites for every kilogram of applied N (Agronomic N efficiency) Hindmarsh⑪ added significantly more yield than both Commander⑪ and Buloke⑪ (Table 2). Hindmarsh⑪ also achieved a greater protein yield in response to applied N. These data suggest that Commander⑪ and Buloke⑪ may have a reduced ability to convert applied N into GY and GPC compared to Hindmarsh⑪. In situations where soil N status is low, a GY response to applied N is likely to be greater in a more responsive variety like Hindmarsh⑪. Under higher yielding and low fertile situations growers may need to apply more N (relative to other varieties) on low GPC varieties Buloke⑪ and Commander⑪ in order to achieve protein standards. Commander⑪ and Buloke⑪ may also be beneficial under conditions conducive to high grain protein levels which have been historically a problem in SA.

Table 2. The mean Agronomic N efficiency (kg/kgN) and Protein Yield (kg/ha) of Bulokeᶲ, Commanderᶲ, and Hindmarshᶲ barley in response to three levels of N from N responsive sites in SA

N treatment kgN/ha	Agronomic N efficiency (kg/kgN)			Protein Yield kg/ha		
	Bulokeᶲ	Commanderᶲ	Hindmarshᶲ	Bulokeᶲ	Commanderᶲ	Hindmarshᶲ
0	-	-	-	341	343	332
40	12.2	11.3	19.8	415	422	476
80	9.4	7.05	13.8	499	477	519
LSD (0.05) Var x N	2.3		28kg/ha			

Table 3. Mean GY and GPC responses to the same N supply applied either early (sowing) or delayed (applied at onset of stem elongation) across sowing dates in Commanderᶲ in trials from 2010 – 2012 (Hart and Tarlee)

Sowing time	Yield kg/ha			Protein (%db)		
	Nil	Early N	Delayed N	Nil	Early N	Delayed N
Early Sowing	4114	5056	4931	8.3	9.9	10.4
Delayed sowing	4131	4790	4381	9.4	10.3	11.2
LSD (5%) Sow date x N	255			0.41		

Improved management of Commanderᶲ barley - sowing date and N timing

Increasing upfront N and sowing Commanderᶲ into paddocks high in residual N is not always desired as Commanderᶲ can be susceptible to lodging in high yielding environments. Canopy management techniques such as earlier sowing coupled with delayed N application closer to the onset of stem elongation may provide the best long term management strategy to consistently achieve maximum yield and quality requirements in low protein varieties such as Bulokeᶲ and Commanderᶲ. Later applications of N to improve the ability to manage protein in Bulokeᶲ and Commanderᶲ, whereas N has been best applied early in more responsive varieties such as Hindmarshᶲ. Moving the same amount of N supply away from sowing to early stem elongation improved GPC on average by 0.5% at early sowing without a yield penalty in Commanderᶲ (Table 3). At earlier sowing dates there is more opportunity to manipulate the crop canopy with N management to improve protein. The same strategy applied at delayed sowing increased GPC on average by 0.9% but resulted in a significant yield penalty. This research demonstrated that similar yields but higher proteins can be achieved without increasing N supply but by shifting N applications away from sowing to early stem elongation.

Acknowledgements

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Review of sulfur strategy to improve profitability in canola in the central west of NSW

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GRDC project codes: GOA00001, DAN00129, NGA00003

Keywords

sulfur, canola, nutrition, sulfur deficiency, KCl-40, soil test, yield, oil

Take home messages

- **Three years of trialling by GOA has consistently failed to demonstrate a significant response to the addition of sulfur (S) in yield or oil%.**
- **Numerous trials by other organisations recently have also failed to demonstrate responses to sulfur in canola.**
- **Sulfur deficiency in canola, when it occurs, can be severe but not always. The frequency of such deficiency is most likely lower than thought and can be rectified early in crop without ongoing penalty.**
- **Unwarranted applications of 20kg/ha of S is reducing the profitability of many canola crops and rates should be reviewed to maintenance levels of 4 kg/t of grain removed. If soil levels are adequate this may be reduced even further.**
- **Canola is more frequently responsive to nitrogen applications and at least some expenditure on fertiliser may be better redirected from sulfur to nitrogen applications.**
- **Soil test critical levels are un-calibrated and are most likely too high and should be reviewed.**

Introduction

Canola has been generally accepted as having high requirements for sulfur (S), much higher than that of wheat. S deficiency was first identified in 1988 and 1989 but was only noted as a significant problem in 1990 (Coulton & Sykes, 1992). Literature from that time and since suggests that deficient situations lead to significant yield and oil penalties where it occurs.

In 2010 Grain Orana Alliance (GOA) established four trial sites investigating the effect of S fertiliser forms and timing on canola performance. In particular, final seed oil % was of interest. None of these trials resulted in any response to S fertiliser in yield or oil % regardless of form or timing.

Following on from this result, GOA questioned why responses were not seen despite prediction that three of the sites would respond. Was it because of changes in our farming systems, a vagary of the particular season; as one of the wettest on record, or because our understanding of S nutrition of canola and its occurrence was incorrect?

In 2011 and 2012 GOA established eight and four trials, respectively to improve our understanding and better identify situations where S deficiency or responses will occur. However, none of these trials responded to S in yield or oil % either.

In 2013 GOA established another four trials investigating aspects of canola nutrition including the responsiveness to S. No response to S was demonstrated in these trials either.

During this period a number of other agencies also conducted trials investigating S nutrition in canola. The results of these will be discussed in this paper and these too have not realised any S responses.

The results from these recent trials should challenge our understanding and approach to S nutrition in canola and a number of specifics listed below will be discussed in this paper such as;

1. The frequency and likelihood of deficiencies in the central west of NSW,
2. critical soil test levels,
3. grain removal rates and nutrient budgeting; and
4. new approaches to S nutrition in canola.

Background

Unreliable yields and crop failures of canola in the late 80's and early 90's were suspected of being due to S deficiency. With the identification of these deficiencies, a series of 14 trials were established in 1992 in collaboration with CSIRO, UNE, Incitec and NSW DPI. These trials investigated the interaction of N and S and if higher N rates were exacerbating S deficiency (Sykes, 1990).

It was quoted in a report by ACIL consulting (1998) that the trials' responses in 1992/3 were 'dramatic', particularly when following pasture. It also states that the trial collaborators, reported from the series of trials that 'applying 20-30kg/ha is sufficient to achieve maximum yields' and 'the best practice for maximising yield with the least risk versus cost trade off'. It is probable that all subsequent recommendations for S application in canola in most industry resources to current date are originally sourced from this one statement, albeit shortened without reference to the later part.

This recommendation was widely adopted and still accepted today as quoted in the 2009 BMP guide for canola;

> 'All paddocks sown to canola should receive 20kg/ha of sulfur in the form of available sulphate. On lighter soil with a history of deficiency symptoms increase rates to 30kg/ha.'

This practice will be referred to as Current Recommended Practice or CRP.

The adoption of this recommendation was rapid; it was estimated that even before the completion of the trials, 90% of canola was receiving the additional levels of S recommended. One of the key factors that supported this rate of adoption was the relatively low cost of S fertilisers at the time which was outweighed by the risk of penalty in deficient situations (ACIL, 1998).

During the same period in the early 90's the KCl-40 soil test for S was introduced and gained adoption as a more appropriate test method than the existing MCP method, however this superiority was demonstrated primarily on pasture sites. (ACIL, 1998)

The KCl-40 test was then widely used for estimating soil S levels particularly for canola. However there is very little evidence for NSW of yield performance against soil tests, until recently with Anderson *et al.* (2013) reviewing past trials. Therefore assumedly, soil critical levels were based upon values extrapolated from critical levels for pasture situations and/or simply on the base blanket recommendations of 20-30 kg/ha of S.

Local trial work by Mullen and Druce between 1993 and 1998, demonstrated that responses to S were not common on heavy grey soils of the region due to S contained in the subsoil. Through this work, S fertiliser applied on these soil types is not common but all other soils in the GOA region commonly still receive the standard 20kg/ha of S.

More recently, trial work by Khan *et al.* (2011) had questioned the suitability of gypsum as an S source for growing of canola compared to sulphate of ammonia (SOA). Gypsum is a commonly used fertiliser in the GOA region and it was questioned if this was contributing to lower oil % in our crops and/or suppressing yields due to S deficiencies.

Khan's findings were part of the basis of the first four trials run by GOA in 2010 investigating S sources and application timings. None of the trials responded to S in any form or timing despite predictions by soil analysis and experience to the contrary. This work is briefed in 'Sulfur Nutrition in Canola - Gypsum vs. SOA and Application Timings' (Street, 2011).

Following this outcome and other questions raised in above mentioned paper, GOA continued this work. Trial design was revised to better mimic the original trial work with the simple aim to quantify a response and also help build on the predictability of response.

Recent findings

Summarised below are the findings from recent trial work investigating S responses in canola. For specific trial detail, please refer to individual trial reports. Unless otherwise stated all statistics are analysed at the 95% confidence level.

GOA trials – 2010 (GOA1001-1004)

Four sites were selected in winter 2010 across the GOA region. Three sites were identified through recent KCl-40 soil tests as being low- moderate in S. The fourth site was deemed adequate in S by way of KCl-40 soil tests.

Treatments addressed three rates of S applied - 0, 15 or 30kg/ha, in two forms (gypsum or SOA), applied at five different timings from pre-seeding to early flowering.

Table 1. Canola yield and oil % performance to applied S fertiliser, GOA 2010

Site	Total S 0-60cm kg/ha #	Site Av. yield t/ha	Yield response to S	Oil % response to S
Nyngan	1.4kg	2.5	n.s.d	
Narromine	85kg	2.2	n.s.d	
Curban	39kg	2.8	n.s.d	
Wellington	23kg	2.2	n.s.d	

*# calculated S total = (KCl40 * bulk density * depth)*

There was no significant difference between any treatment and UTC at 95% confidence levels in yield or oil % as assessed by ANOVA.

GOA trials – 2011 (GOA1101-1104 plot sown trials) (GOA1110-1113 farmer sown trials)

Four plot sown sites and four farmer sown replicated trials were established in 2011. All sites were selected for low soil S with the details below.

The small plot sown trial protocol was changed in 2011 to a full factorial trial design with two nitrogen (N) rates (50 & 100kg N/ha) and five S rates (0, 5, 10, 20 & 30kg S/ha). All fertiliser treatments were predrilled immediately prior to sowing. S was supplied in the form of granular SOA (20% N, 24% S) and the N rates adjusted using urea (46% N).

Yield results were analysed by factorial analysis (ANOVA) with the outcome listed in the table 2.

There was no response to added S in yield or oil %. Three of the sites demonstrated strong positive and statistically significant responses to increased N rates from 50kg/ha of N to 100kg/ha. Yield responses were 18% increase at Geurie, 32% at Warren and 42% at Curban.

The four farmer sown trials were small plot replicated trials. The trials were established on farmer sown paddocks on soils of low S backgrounds. These trials were only designed to provide further support to the more comprehensive plot sown trials and treatments were reduced to basic plus and minus S.

The treatments were broadcast ahead of rain during the vegetative stage and were:

1. No N or S added or UTC
2. S added in the form of SOA at 100kg/ha (21kg/ha N & 24 kg/ha S)
3. N added as urea at 45kg/ha (21kg/ha N) to supply the equivalent amount of N contained in the SOA treatment

The outcomes analysed by ANOVA are listed in the table 3.

Table 2. Canola yield performance to increasing applied S or N fertiliser, GOA 2011

Site	Total N 0-70cm kg/ha #	Total S 0-70cm kg/ha#	Trial av. Yield	Yield response	
				Nitrogen	Sulfur
Geurie	62	35	1.68	+0.28 t/ha	n.s.d
Curban	37	40.4	0.84	+0.3t/Ha	n.s.d
Warren	39	30.1	0.97	+0.26 t/ha	n.s.d
Narromine	44	42	2.03	n.s.d	

*# calculated N/S total = (soil test value * bulk density * depth), NB- Oil % was not available for this set of trials*

Table 3. Canola yield and oil % performance to applied S or N fertiliser, GOA 2011

Site	Total Soil S kg/ha #	Trial Av. Yield t/ha	Yield Response	Oil % Response
Wongarbon	No S applied in 14 years	1.7	n.s.d	n.s.d
Coolah Black	33	0.9	Urea or SOA suppressed yield over UTC	n.s.d
Coolah Red	31	1.06	n.s.d	n.s.d
Arthurville	24	2.3	n.s.d	n.s.d

*# calculated S total = (soil test value * bulk density * depth) Soil sampled to 60cm depth*

As shown above, the only interaction achieved in these trials was a reduction in yield to applied S at Coolah. This reduction however was achieved with both urea and SOA which could indicate this was due primarily to the added N in both treatments, not the S. The resulting reduction in yield could be attributed to the dry conditions in late winter and spring experienced in 2011 at this site and over fertilisation with N, supported by the low average trial yield.

GOA trials – 2012 (GOA1201-1205)

GOA repeated the same plot sown protocol employed in 2011 on a further four sites in 2012.

Yield and oil % results were analysed by factorial analysis (ANOVA) with the outcome listed in the table 4.

In 2012 there was no response to added S in yield or oil %. In two of the trials there was a significant response to increasing the N from 50kg/ha to 100kg/ha in yield. At the Wellington N site, yield was increased by 24% with the increased N rate and by 7% on the second site.

DPI collaborative trials 2012 (GOA1206 and 1207 or NSW DPI site)

In 2012, in collaboration with the NSW DPI, two trials were undertaken at Trangie and Coonamble. The trials were a factorial design with four N rates (0, 25, 50 & 100kg/ha) and four S rates (0, 10, 20 & 30kg/ha) and two canola varieties in Pioneer®43C80 and Pioneer®44Y84 sown at the Trangie site but only Pioneer®44Y84 sown at the Coonamble site.

Yield and oil % results were analysed by factorial analysis (ANOVA) with the outcome listed in the table 5.

At the Coonamble site there was no response to the addition of N or S in either yield or oil %.

Table 4. Canola yield and oil % performance to increasing applied S or N fertiliser, GOA 2012

Site	Total N 0-70cm kg/ha#	Total S 0-70cm kg/ha#	Trial av. Yield t/ha	Yield response		Oil % response	
				Nitrogen	Sulfur	Nitrogen	Sulfur
Narromine	75	18.3	2.79	n.s.d		n.s.d	
Curban	88	33.8	1.27	n.s.d		n.s.d	
Wellington N	32	37	0.61	+ 0.13t/ha	n.s.d	n.s.d	
Wellington S	71	50	1.4	+ 0.1 t/ha	n.s.d	n.s.d	

*# calculated N/S total = (soil test value * bulk density * depth)*

Table 5. Canola yield and oil % performance to increasing applied S or N fertiliser, DPI/GOA 2012

Site	Total N 0-90cm kg/ha#	Total S 0-90cm kg/ha#	Trial av. Yield t/ha	Yield response		Oil % response	
				Nitrogen	Sulfur	Nitrogen	Sulfur
Coonamble	73	20	2.56	n.s.d		n.s.d	
Trangie	113	141	1.81	+ 0.35 t/ha	n.s.d	-1.60%	n.s.d

*#calculated N/S total = (soil test value * bulk density * depth)*

The Trangie site resulted in no significant response to S in yield or oil % but would not be expected given soil S levels. There were significant responses to N in yield and oil %. Increasing N rates increased yields but decreased oil %. There was a significant response to variety with Pioneer®44Y84 outperforming Pioneer®43C80 in both yield and oil % (data not presented).

DPI northern region trials 2012 (NSW DPI Northern trials booklet)

DPI established two trials in Northern NSW investigating N and S interactions.

The trials were a factorial design with four N rates of 0, 40, 80 and 120kg/ha at Moree and 0, 50, 100 and 200 kg/ha at Blackville both with four S rates of 0, 11, 21 & 41kg/ha and two canola varieties. Nitrogen was applied as urea with sulphur applied as granulated gypsum applied pre sowing.

Yield and oil % results were analysed by factorial analysis (ANOVA) with the outcome listed in the table 6.

There was no response to added S at either site in yield or oil % as would be expected with such high levels of soil S. Both sites responded strongly to the addition of N, in yield the response was positive but both negative in oil %.

NGA trials 2012 (AM1201, RH1207)

NGA established two trials in 2012 investigating nutrition of canola in the northern region. The trials investigated the interaction of N and S as well as phosphorus (P).

The trials were a factorial design with three N rates of 34, 84 and 134kg/ha with three S rates of 1, 16 and 31kg/ha. Nitrogen was applied as urea with sulphur applied as Gran Am (SOA) applied pre sowing.

Yield and oil % results were analysed by factorial analysis (ANOVA) with the outcome listed in the table 7.

There was no response to added S at either site in yield or oil %. At both sites there was a positive response to increasing N rates, 13% at Bellata and 20% at Yallaroi. At Bellata there was a negative response in oil % to increased N rates. The Bellata site responded to added P, at the Yallaroi site there was a trend to increase with added P but was not significant (not in the table).

Table 6. Canola yield and oil % performance to increasing applied S or N fertiliser, DPI 2012

Site	Total N 0-90cm kg/ha#	Total S 0-90cm kg/ha#	Trial av. Yield t/ha	Yield response		Oil % response	
				Nitrogen	Sulfur	Nitrogen	Sulfur
Blackville	28	130	1.54	+ 1 t/ha	n.s.d	-0.79%	n.s.d
Moree	46	94	1.15	+ 0.74 t/ha	n.s.d	-1.60%	n.s.d

*#calculated N/S total = (soil test value * bulk density * depth)*

Table 7. Canola yield and oil % performance to increasing applied S or N fertiliser, NGA 2012

Site	Total N 0-90cm kg/ha#	Total S 0-90cm kg/ha#	Trial av. Yield t/ha	Yield response		Oil % response	
				Nitrogen	Sulfur	Nitrogen	Sulfur
Bellata	69	164	1.37	+ 0.15 t/ha	n.s.d	-2.80%	n.s.d
Yallaroi	30	NA	1.79	+ 0.31 t/ha	n.s.d	n.s.d	

*#calculated N/S total = (soil test value * bulk density * depth)*

Central West Farming Systems (CWFS)

CWFS have undertaken a number of trials at their regional sites investigating canola S nutrition over a number of seasons (www.cwfs.org.au). Unfortunately individual trial data was not available at the time of writing this paper but personal comments regarding their trials over recent seasons by John Small (CWFS) are below.

'There has been no clear or statistically significant response to the addition of S in terms of yield or oil performance in canola over a number of trials by CWFS over recent seasons.'

Readers should seek further clarification and data from CWFS concerning these trials before finalising one's conclusion. The outcomes of these trials will however be valuable in the sense that they would generally be undertaken on red soils of our region, more likely to respond than the heavier soils of the northern regions.

Discussion

As indicated above there has been no response to S in terms of yield or oil % in recent trial work. This work has been undertaken by a number of agencies across a range of soil types and three seasons. It should also be noted that all but one of GOA's trial sites were selected specifically for low soil S levels and were predicted by soil tests to be responsive.

Why have responses not been achieved?

As stated above, CRP is that all canola paddocks should receive S fertiliser. However of the original trial work that formed this recommendation only six of the fourteen sites detailed responded to S in yield and only three in oil % (Sykes, 1990). Many of these sites did not respond despite prediction by soil tests.

The most commonly reported trial was at the Wellington site where yields increased from 1t/ha to 4t/ha with the addition of S. At this site 75% of the site maximum yield was achieved at 10kg of S/ha, and 92% at 20kg/ha of S applied. A similar result was demonstrated at Baradine, but these could be described as the two worst documented cases of S deficiency.

Many of the other responsive sites did not realise such magnitude of improvement. At the Gollan site at the 40kg N/ha rate- increasing S from 0 to 20kg/ha only increased yields by 590kg. At 80 kg N/ha rate- there was a 325 kg/ha improvement by increasing S from 0 to 20 kg/ha. At the Junee Reefs and Tamworth sites a maximum response was achieved of approximately 400 kg/ha. These were then and would still be now, worthy economic responses on today's fertiliser prices but the penalties nowhere close to the extent that is often promoted.

The ACIL report also mentions other previous work in 1990 commenting, 'A major field study of canola in NSW reported significant grain yield increases from the addition of N but no significant responses to S (Sykes and Coulton, 1990)'.

More recent work as detailed above shows no response to the addition of S over three years and a range of soils predicted to respond.

In summary, the frequency of response to added S is quite low, considering just the detailed trials in this paper less than 14% of trial sites were responsive (excluding the field study of 1990 and those of CWFS). In terms of recent trials, 0% responded to added S.

Industry accepted grain removal rates used in nutrient budgets may also lend support to the CRP. Current industry references suggest that removal rates are 10kg S/ t of grain and that crop requirements of canola are much higher than that of wheat (Coulton *et al*, 1992).

Analysis of grain samples from GOA's and NGA's trial work have shown that grain removal is much lower than these levels. Published data by Janzen and Bettany (1994), Pinkerton *et al*. (1993) and Hocking *et al*. (1996) all measured grain S contents in their range of experiments. Grain S levels no greater than that of ~0.5 % or 5kg S/t of grain was measured, even in treatments with adequate S. In many cases the S levels were even lower resulting in them being less than half the industry benchmarks.

When considering this for formulating crop requirements and fertiliser programs there may be little difference between the removal for wheat or canola. For example an average wheat yield for the GOA region may be 3 t/ha, removing approximately 1.8 kg/t of S or 5.4 kg/ha of S. Canola will generally perform at 50% of comparable wheat yields (Parker, 2009) so 1.5t/ha crop, removing 3.6 kg/t. The critical threshold described by Hocking *et al*. (1996) will remove only 5.4 kg/ha of S or similar amounts to the wheat crop.

So a possible explanation of the lack of responsiveness in all of these trials was that the prediction regarding the sites' responsiveness was misleading. These predictions, were supported by a crop demand much higher than what seems apparent now, and therefore, was there adequate S contained in the soil profile and subsequent mineralisation to satisfy crop demands?

For example, using the highest achieved yield in the GOA trials of ~ 2.8t/ha the crop removal rate would be 9.8 kg/ha. If we assumed an arbitrary uptake or transfer efficiency of 50%, the crop would only have a growing requirement of 20 kg/ha. All of the sites detailed in this paper would have satisfied this requirement with starting soil levels and only a minimal amount of mineralisation; no additional fertiliser would be required.

So what is the critical soil level to indicate when S may be required to be added?

To supply this requirement of 20kg/ha of S a soil KCl-40 test would have a critical level of ~2.3 mg/kg averaged in the top 60cm of soil depth (i.e. 2.8t/ha * 3.5kg/t / 50% = crop requirement/1.4 (soil bulk density) / 6 (10 cm soil segments)). If this is indeed the soil critical level, few cropping soils would be lower.

But what of the sites that did respond in 1992?

Interestingly the second most responsive site was at Baradine. Although details of soils tests are scant, the report by Sykes indicates there was some 675kg of S available at this site, certainly enough to satisfy crop requirements. Was the response at this site a function of availability within the effective root zone for that crop? If the subsoil was dry that year and as such the crop was not able to access this nutrient layer, deficiency is possible despite significant soil reserves.

This view could also explain by the trial at Andersons from 1992 where early deficiency symptoms were seen in the crop but despite this the nil S plots recovered to result in no yield response possibly when rain fall and root development accessed adequate S reserves deeper in the soil.

S is mobile in the soil and susceptible to leaching from the topsoil and accumulating at depth. Low or no subsoil starting moisture due to the farming system of the time or seasonal or locality differences could foreseeably see crops sown into circumstances where deficiency may be experienced if the crops cannot access the reserves accumulated deeper in the soil. Later season rainfall, wetting the soil deeper may see the crop being able to access these reserves and rectify without action any earlier deficiencies.

Anecdotally deficiency is often noted more in the southern regions with less summer rain to wet the profile to depth prior to planting.

The new paradigm in canola nutrition

Reducing Sulfur fertiliser rates

When considering fertilising canola, a distinguishing difference from most other field crops is its S requirement. As such, it is often the first nutrient addressed after that of starter P fertiliser applications in fertiliser programs and its requirement of N then follows.

More than 20 trials run over the past three seasons that have been briefed above have failed to demonstrate responses to added S in either yield or oil %. Average crop removal rates do not support the requirement of 20kg S/ha universally.

Given this scenario, reducing the CRP of 20kg/ha of S to rates which more closely match crop yields and subsequent removal rates would certainly be a more economic approach whilst being sustainable in the longer term.

However the complete lack of S response in recent trials raises the possibility of completely removing intended S applications as it is done in wheat. Given there is often no yield or oil % response, profitability in the short term will only decline with any additions of S.

However if growers are to take this this approach, soil tests may still be useful to predict potential responsiveness if using removal rates. If soil level concentrations and subsequent calculations of soil available S outstrip the predicted conservative crop requirements at 4-5 kg of S/t of crop potential, the likelihood of crop responses or a deficient situation developing is unlikely.

In these situations of no S applications, growers do risk that deficiencies may develop despite prediction to the contrary. If this deficiency is identified prior to stem elongation and S applied, trial work by Hocking *et al*. (1996) showed that both final yield and oil % will not be penalised. But remember the frequency of such a deficiency on the basis of recent trial work is low but not zero.

However consider the location of this S, whether deep or shallow in the profile, and the crops likely ability to access it. Low subsoil moisture at planting and low in crop rainfall may see deficiencies experienced and surface applications warranted. However if sufficient rainfall through the growing season wet the soil deeper allowing plants to access this deeper S, deficiencies may be alleviated.

Re-focus investment on nitrogen instead of sulfur

In contrast, the majority of all trials have demonstrated response to N.

Twelve of the fourteen trials undertaken in 1992 resulted in significant and economical responses with an average increase to 80 Kg of N of 600kg/ha (Sykes, 1990). Of the two that did not, one of the trials was following five years of grass free legume based pasture; the other was compromised by frost resulting in a high trial CV.

Three of the four trials of GOA's in 2011 responded significantly to increasing N from 50kg/ha of N to 100kg/ha. The average yield increase over the three sites was 280kg/ha returning around 200% ROI (canola at $500/t and urea at $700/t). Two of GOA's trials in 2012 returned a significant yield response to increasing N as well. Returns were much lower with the dry spring conditions with the yield increases only breaking even after additional costs.

Trials by NGA in 2012 demonstrated a 13% yield increase or about 150kg/ha (break-even) by increasing N from 34 kg/ha to 84 kg/ha in one trial. The second site saw an increase yield of 20% or ~310kg/ha, resulting in approximately a 200% ROI.

It should be noted that GOA's and NGA's trials did not have zero N treatments but they were all clearly N responsive sites.

In the DPI/GOA trials in 2012 treatments of 0 N were included and this allows a response curves to be generated. The Trangie site showed strong responses to N with yield increasing by 0.35t/ha or 21% by increasing N from zero to 100kg/ha. The economics of such applications are demonstrated in Figure 1.

Columns headed by the same letter denotes no significant difference

Although the starting soil N at this site was high at 113kgha, yield and resultant gross income has increased almost in a linear response and the treatments have not demonstrated a clear upper limit. The responsiveness of canola to high rates is reinforced at three other sites detailed in Figure 2; again there was no clear indication of a yield plateau even up to 200 kg N/ha.

So although canola will tend to respond to increasing N, the ROI declined beyond the 25kg/N rate but still remained positive. This is only one trial in a dry spring but it demonstrates that the most economical rate is not necessarily the point of yield

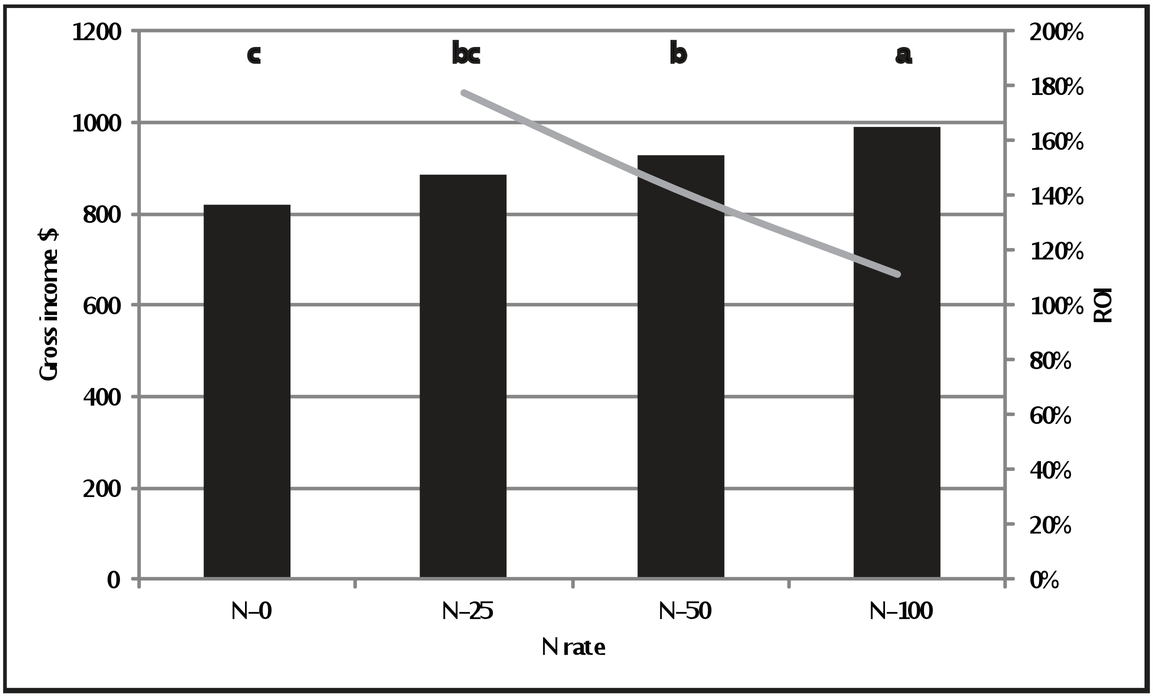

Figure 1. Canola yield performance in relation to applied N rate and the corresponding return on investment (ROI), Trangie (Source: DPI/GOA (2012)).

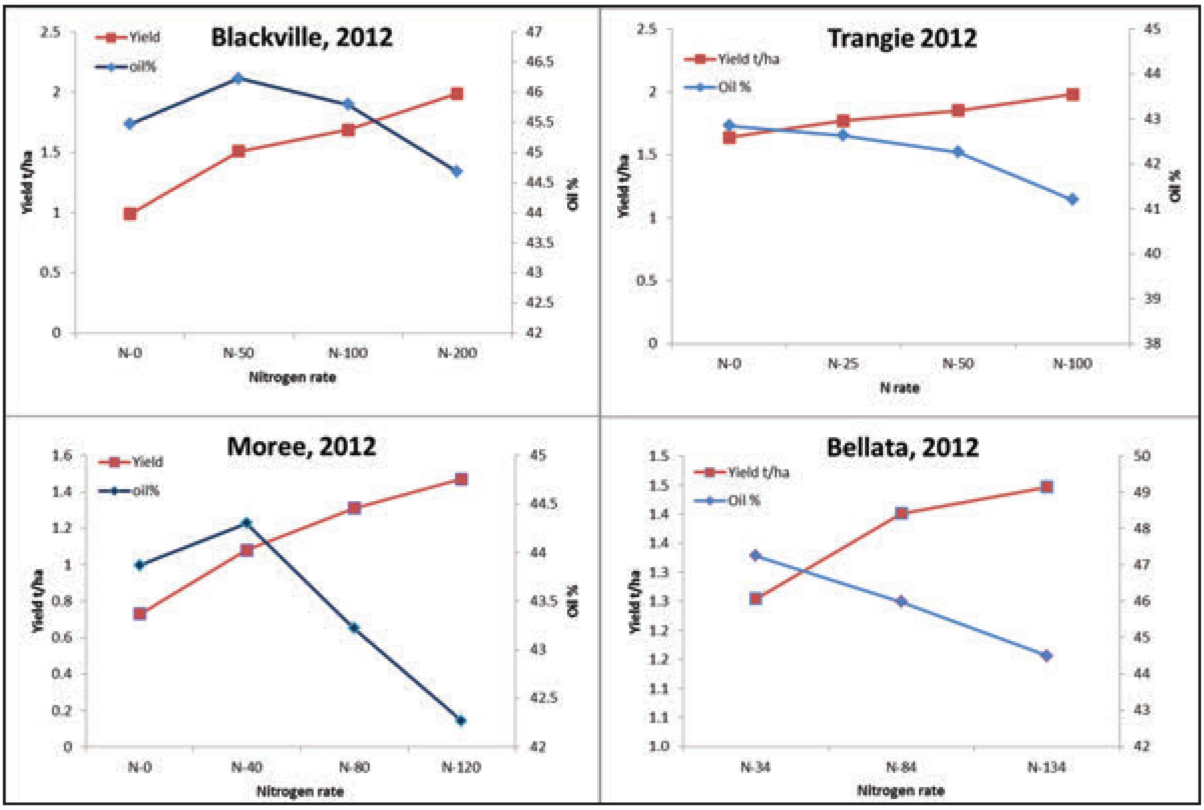

Figure 2. Canola yield and oil % performance demonstrating the inverse relationship to applied N (Source: DPI/NGA/GOA (2012)).

maximisation. The economically optimum level for N rates may be different for each situation.

Determining the optimal N rate for canola through deep soil tests coupled with yield forecasting may be one approach and probably the most reliable.

It is worth noting that increasing N rates may have the effect of reducing oil % as demonstrated in the Trangie, Bellata, Blackville and the Moree trials (Figure 2). Many of the trials from 1992 also showed statistically significant reductions in oil content from increased N rates. Increased N can lead to increased protein. Protein's relationship to oil % is inverse so this can lead to depressed levels of oil. However in all cases the increased yield more than adequately offset this loss.

Summary

In summary, 20 trials have now recently been undertaken across a number of seasons and locations in NSW. None of them have demonstrated S responses in yield or oil %. This does not exclude deficiency and yield penalties from occurring but does highlight that the frequency and the likelihood is not high.

The results and the ensuing extension message regarding the need for S from the trial work in 1992 may have lost its original perspective. Within the original reports, the data suggested that N was paramount to achieve maximum profitability for canola in nearly all cases. The data also suggested that in only some cases canola responded to S as well.

However, the one extension message that resulted and stuck was that all canola crops needed 20 kg/ha of S and sometimes more needed to be applied. The then lower cost of S fertiliser and the significant penalties seen in deficient situations, saw this recommendation adopted rapidly, whether S was needed or not.

Declining terms of trade over the last 20 years, does not allow now for such a luxurious approach to be taken, particularly if not warranted.

Through GOA's efforts a number of shortcomings in the understanding of canola agronomy have been highlighted. Removal rates are over-estimated and the lack of calibrated soil critical levels is a major problem. Improvement in both of these may improve the predictability of S responsiveness.

With the reduced frequency of response and considering the reviewed S demand of canola, the CRP may need revision to closely match S removal rates. This will result in increased profitability and sustainability for growers.

Complete removal of S from fertiliser programs may be risky but will prove to be the most profitable practice in many cases. However, wheat has a similar requirement per hectare, and the predominant fertiliser applied is MAP/DAP which contains only minimal S and wheat is not noted to suffer yield impacts through deficiencies. And it should be remembered deficient situations can be easily rectified by in crop applications.

There is a good case for the savings in expenditure on S to be redirected to N where the response is much more common. But determination of the optimal rate of N may need to be revisited or targeted through soil tests and nutrient budgets to ensure the return on investment is maximised not simply the yield.

'Current recommendations consider S to be non-negotiable and N applications more seasonally dependent. This approach needs to be reversed; S application needs to be more prescriptive in its use and we need to refocus our attention and redirect our expenditure on getting our N rates right.'

Additional information

www.nga.org.au

www.grainorana.com.au

www.dpi.nsw.gov.au/agriculture

www.cwfs.org.au

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Exploring herbicide tolerance in lentils

Chris Davey,
YP AG

Keywords

texture, group B, lentils, tolerance, rate, timing, residual, milk thistle

Take home messages

- **Early vigour is closely related to lentil yield.**
- **Factors that determine the safety of the post sowing pre-emergent (PSPE) application include; lentil variety tolerance, sowing depth, chemical type, soil moisture at the time of sowing and rainfall received after application.**
- **The texture and pH of the soil determines the type and rate of chemical used for weed control in lentils.**
- **The introduction of Herald XT⌽ and Hurricane⌽ lentils will add flexibility to farmers' rotations.**
- **Milk thistle and prickly lettuce are both problematic weeds in lentils and require attention to control them before the lentil crop has emerged. Group C chemicals like Diuron, Simazine, Metribuzin and Terbuthylazine all have activity on these weeds.**

Introduction

The characteristics of the northern soils associated with the Northern Sustainable Soils farmer group are mainly their light and sandy texture, alkalinity and calcareous nature.

The sandy texture means that nutrients and chemicals are rapidly leached down the profile, and therefore, the selection of chemical rate is difficult due to the leaching nature of the chemical as well. Generally, lower rates are selected for the safety of the crop. The pH of 8 to 9.5 of the soil means that Group B chemicals have long half-lives and do not break down rapidly in the soil. The use of this group has decreased in the past 15 years so farmers have the flexibility to grow conventional lentils in their rotation.

Lower rates of the moisture activated chemicals in all Group C's used in lentils have to be chosen so little crop effect is observed. The chemical moves quickly in the soil under wet conditions, so the residual properties of the chemical are reduced. This normally results in poorer weed control and some times, crop damage.

Until the introduction of Herald⌽ and Hurricane⌽ lentils, Group B chemicals with high residual properties were avoided and care had to be taken with rotations.

For the past three years, these trials have been funded by the Northern and Yorke Natural Resource Management board (NYNRM) and the GRDC. The aim of the trials has been to assess the tolerance of lentils to different, and in some cases off-label, herbicides in sandy, light soil types.

Lentils are a high gross margin crop, so careful consideration has to be taken when growing them in such an area. Chemical effect, or crop damage, can result in yield loss, higher risk of erosion over summer, poorer nitrogen fixation, and poorer weed competition.

All of these factors lead to a lower level of sustainability and profitability in the NYNRM region.

The trials started in 2011, looking at some commonly used pre-emergent broadleaf chemicals and their effect on lentils.

Table 1. Lentil herbicide tolerance at Port Broughton in 2011

	Pre-emergent	PSPE	Post-emergent	Vigour	Yield	% of UTC
1	Untreated control (UTC)			10.0 a	1.64 a	100
2	Metribuzin 120 g	Metribuzin 60 g		9.7 ab	1.59 ab	97
3	Metribuzin 120 g			9.3 abc	1.51 abc	92
4	Metribuzin 120 g		Brodal® 180 mL	8.3 bc	1.26 c	77
5	UTC			10.0 a	1.64 a	100
6	Terbyne 1 kg			8.0 c	1.46 abc	90
7	Terbyne 1 kg	Terbyne 700 g		5.3 d	0.89 d	54
8			Brodal 240 mL	9.0 abc	1.36 bc	83
9	EXP 1 L			9.3 abc	1.64 a	100
	Co-efficient of Variation			10%	10%	
	LSD 5%			1.6	0.25	

**Highlighted cells denote NOT REGISTERED and OFF LABEL*

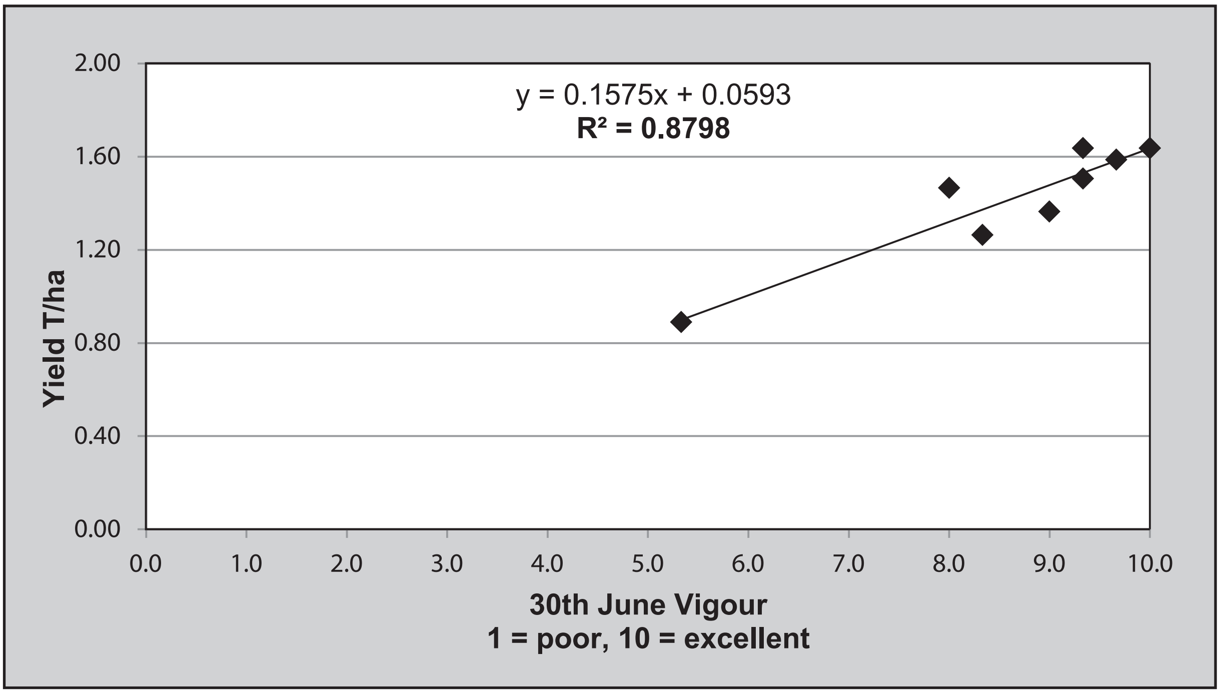

Figure 1. 2011 lentil vigour on the 30th of June versus the final yield.

2011 results

Summary of 2011 results:

- Early vigour is closely related to lentil yield.
- Some chemical is preferred, either PSPE or post-emergent, to control broadleaf weeds in the furrow.
- The practice of applying a PSPE chemical can however, result in crop damage, yield loss or poor weed control under the wrong conditions e.g. heavy rainfall following application, or lack of rainfall afterwards.
- Terbyne was safest when used pre-emergent only. The addition of some Terbyne PSPE severely affected yields. Manufacturers, Sipcam have since released a set of guidelines for use of Terbyne on lentils.
- In 2011, Brodal did have some effect on the yield of lentils at Port Broughton. A prolonged dry spell occurred after this application, which may have compounded the effect.
- Be aware of stubble loads and the effect it can have on these chemicals.
- Levelling the surface can affect the result as well.

2012 results

Summary of 2012 results

- There was an effect from the Terbyne use again for season 2012.
- The split application had a worse NDVI than the all 'up-front' treatment.
- The experimental usage of Valor as a residual chemical would appear not to be advisable.
- The increase in NDVI from the use of Propyzamide was mainly from the amount of milk thistles present in these plots. Propyzamide does not control milk thistle. If it does get used in the field, another chemical like a Group C triazine should be added to the tank mix.

Table 2. Lentil herbicide tolerance at Port Broughton in 2012

	Pre-emergent	PSPE	Post-emergent	NDVI RI%	Yield	% of District Practice
1	Metribuzin 120 g	Metribuzin 60 g		100	1.80	100
2	Terbyne 1 kg			100	1.25	69
3	Terbyne 700 g	Terbyne 300 g		90	1.25	69
4	Simazine + Diuron			104	1.25	69
5	Spinnaker[a] + Diuron			106	1.70	94
6		Valor 90 g		94	0.80	44
7	Propyzamide 1 L			140	1.85	103
8	Propyzamide 0.5 L			138	1.90	106

* *Highlighted cells denote NOT REGISTERED and OFF LABEL; NDVI RI% = Normalised Difference Vegetation Index – Relative Index Percentage (relative to Treatment 1)*

[a] *Registered for use in SA under permit number: PER14369*

Table 3. Lentil pre-emergent herbicide tolerance at Port Broughton in 2013

	Pre-emergent	PSPE	Post-emergent	Milk Thistles	Yield	%
1	Terbyne + Propyzamide	Terbyne + Propyzamide		1.8 a	1.47 a	100
2	Outlook 1 L	Outlook 0.5 L		3.3 ab	1.45 ab	99
3	Propyzamide 1 L			6.8 cd	1.40 abc	95
4	Outlook 1 L			8.8 d	1.35 abc	92
5	Terbyne 1 kg			8.8 d	1.34 abc	91
6	Terbyne 700 g	Terbyne 300 g		1.3 a	1.29 bc	88
7	Propyzamide 0.5 L	Propyzamide 0.5 L		5.8 bc	1.29 bc	88
8	Metribuzin 150 g	Metribzuin 50 g		5.0 bc	1.26 c	86
9			Metribuzin 180 g	7.3 cd	0.97 d	66
	Co-efficient of Variation			41%	13%	
	LSD 5%			2.5	0.17	

**Highlighted cells denote NOT REGISTERED and OFF LABEL*

Table 4. Lentil group B herbicide tolerance at Port Broughton in 2013

	Pre-emergent	PSPE	Post-emergent	Yield	%
1	Logran 15 g			1.74 a	100
2	Ally 7 g			1.71 ab	98
3		Spinnaker 70 g	([a]reg'd post-em)	1.64 abc	94
4		Intervix 750 mL		1.55 abc	89
5		Broadstrike 25 g		1.50 bc	86
6	Spinnakera 70 g			1.45 c	83
7		OnDuty 40 g		1.41 c	81
8		Ally 5 g		0.43 d	25
9		Crusader 500 mL		0.28 d	16
10		Glean 10 g		0.23 d	13
	Co-efficient of Variation			18%	
	LSD 5%			0.23	

* *Highlighted cells denote NOT REGISTERED and OFF LABEL*

[a] *Registered for use in SA under permit number: PER14369*

2013 results

Summary of 2013 pre-emergent herbicide results

- Metribuzin used as a foliar application is not registered and can cause severe crop effect.
- Terbyne proved to be the best chemical or tank mix partner to control milk thistle.
- Factors that determine the safety of PSPE application include lentil variety tolerance, sowing depth, chemical type, soil moisture at the time of sowing and rainfall received after application.

Summary of 2013 group B herbicide results

- There is a large variation in tolerance to Group B chemicals by Herald XT⦶ lentils.
- Most of the treatments applied in this trial are not registered for use in lentils.
- Herald XT⦶ (and Hurricane⦶) lentils are tolerant to Spinnaker at label rates, have increased tolerance to Broadstrike and improved tolerance to residual levels of sulfonyl urea chemicals.
- The use of OnDuty, Glean, Ally and Crusader at the PSPE timing should be avoided due to the significant yield loss measured in this trial.
- Despite the lack of registration, the use of Group B sulfonyl urea chemicals like Ally, Glean and Logran prior to seeding did not result in a decrease in yield.
- All Group B chemicals do not have activity on weeds such as, prickly lettuce and milk thistle on NYP, so it is recommended that a tank mix partner be added to assist with the control of these problematic weeds.

Acknowlegement

Leighton Wilksch, Lynton and Avan Ireland, NSS Committee and NYNRM

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Notes

Pulse varieties and agronomy update

Michael Lines[1], Larn McMurray[1], Jason Brand[2], Andrew Ware[3], Jenny Davidson[4], Rohan Kimber[4], Jeff Paull[5] and Kristy Hobson[6],

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GRDC project codes: : DAV00113, UA00127, DAV00072, DAV00071, DAN00151, DAS00131, DAS00112, S0213

Keywords

lentil, field pea, chickpea, faba bean, lupin

Take home messages

- **Five new pulse varieties were released for southern Australia in 2013. It is important to carefully assess the agronomic, disease and marketing strengths and weakness of each variety, and their overall role in the farming system.**
- **The warm, wet winter favoured biomass production and early botrytis grey mould onset in lentil and faba bean in 2013. Timely canopy closure fungicide application was critical for reducing yield loss in varieties with intermediate resistance. Consider delaying sowing time in vigorous, high biomass varieties like PBA AceA in disease prone areas.**
- **Weed competition was a major constraint to pulse production in 2013. The availability of imidazolinone tolerant lentil varieties (XT) provides some alternative control options in this crop. A GRDC funded project has successfully developed alternative herbicide tolerances in lentil and faba bean and field validation is expected in 2014.**
- **Stubble management experiments in lentil again showed that substantial yield increases are possible from inter-row sowing into retained stubble providing early season insect and pests are effectively identified and controlled.**
- **New high biomass producing field pea varieties provide the opportunity to improve weed control and spread production risks through a forage or green/brown manuring option, rather than just grain production.**
- **Clethodim resistant ryegrass is becoming a major issue in pulse production and alternative weed control strategies require investigation.**

2013 season in review

- Pulse grain yields were variable in 2013, generally ranging from average to well above average, depending on rainfall distribution and the impact of frost during October. Grain quality was generally good despite high disease and moderate insect (Heliothus and Etiella) pressure in many areas.
- Close to long term average rainfall was achieved in many regions of the state in 2013. Summer and late spring rainfall in 2013 was generally low, however winter rainfall was higher than average, and associated with periods of waterlogging in a number of regions of the state. Low rainfall in late spring resulted in a rapid dry down, however the mild temperatures still enabled later varieties to finish.
- Winter temperatures were generally warmer than average in 2013, with minimal extreme events (heat or cold), and this combined with good winter rainfall resulted in high biomass production and large canopies. Varieties with high biomass (e.g. PBA Ace⏀ lentil) generally struggled to reach full yield potential due to the dry finish to the season.
- Weed control, both broadleaf and grass, proved challenging for pulse crops in 2013 due to the warm and wet winter and early spring conditions. This meant that there were many 'weedy' looking pulse crops in late spring and at maturity. In particular, clethodim resistant ryegrass, medic, vetch and tares were significant issues.
- Plant disease levels varied widely across crops and regions in the state. The most prevalent diseases in 2013 were ascochyta blight and botrytis grey mould in lentils, downy mildew and black spot in field peas, and ascochyta blight and chocolate spot in faba beans.
- There were numerous reports of poor lower-canopy pod set in faba bean crops throughout the state, and yields varied widely as a result. This is thought to be due to a combination of heavy canopies and the large number of overcast days and low temperatures during the early flowering period in 2013 as a consequence of the wet conditions.

Update on new variety releases and agronomic research

Lentil

The amount of disease seen in 2013 was higher than in previous seasons due to the warm winter conditions promoting humidity and growth of large canopies. Ascochyta blight was common early in the season, particularly in PBA Flash⏀, and higher levels of this disease are now being reported on the varieties Nipper⏀ and Nugget than seen previously. This observation provides evidence that the pathogen population is evolving to overcome some resistance genes. Despite this however, the resistance of new varieties PBA Ace⏀, PBA Bolt⏀ and PBA Herald XT⏀ is holding up well.

Botrytis grey mould was widespread in 2013, and the timing of protective fungicides just prior to canopy closure was critical to avoid or minimise yield loss. New varieties PBA Bolt⏀, PBA Hurricane⏀, and to a lesser extent PBA Ace⏀ (due to its large canopy), may require additional protection after this critical stage in favourable environments for disease.

Despite high disease pressure, yields were generally above average in 2013, and recent releases PBA Flash⏀, PBA Blitz⏀ and PBA Jumbo⏀ all performed well. PBA Ace⏀, which has performed exceptionally well in recent seasons, had only slightly higher yields than Nugget in 2013. This was likely due to its high biomass production, which was not suited to the dry finish to the season in 2013 but has favoured this variety in previous seasons with colder winters and smaller canopies. PBA Herald XT⏀ performed below expectations in 2013 compared to all other varieties. It had the lowest level of foliar disease of all commercial varieties during winter and spring but appeared poorly suited to the dry finishing conditions. New varieties PBA Hurricane XT⏀ and PBA Bolt⏀ had variable yields across sites but were generally similar or slightly above Nugget and superior to Nipper and PBA Herald XT⏀.

PBA Hurricane⏀ (CIPAL1101)

PBA Hurricane XT⏀ is the second herbicide tolerant lentil variety, building on the success of the pioneer herbicide tolerant variety PBA Herald

XT⊕. It provides growers with a lentil variety which incorporates improved tolerance to some Group B herbicides, improved agronomic characteristics and higher grain yields than Nugget, Nipper⊕ and PBA Herald XT⊕. PBA Hurricane XT⊕ has an APVMA permit for imazethapyr use ***(product label rates, plant-back periods and all label directions for use must be adhered to).***

PBA Hurricane XT produces small-medium size seed, slightly larger than PBA Herald XT⊕ and NipperA, with a grey seed coat, and shows a 5-12% long term yield advantage over these varieties. It is lower yielding than PBA Ace⊕, PBA Flash⊕ and PBA Bolt⊕, but may be preferred where more flexible weed control is desired. It is a mid-maturity, broadly adapted variety with earlier flowering, improved vigour and increased plant height over PBA Herald XT⊕ and Nipper⊕. Like Nipper⊕ and PBA Herald XT⊕, it is resistant to ascochyta blight (AB), but will require protection for botrytis grey mould (BGM) in disease prone areas, particularly where sown early. PBA Hurricane XT⊕ is free of the black seed-coat seeds which are present in low levels in PBA Herald XT⊕. Herbicide tolerance testing indicates PBA Hurricane XT⊕, like Nipper and PBA Herald XT⊕, is more sensitive to Group C herbicides such as metribuzin than Nugget and PBA Flash⊕, and caution is urged with the application of these products particularly on variable soil types. Seed is available through PB Seeds.

Inter-row sowing lentil into retained cereal stubble

Agronomic trial work conducted by the Southern Pulse Agronomy project in 2010-2012 has shown that substantial yield benefits can be achieved through inter-row sowing of lentil into retained cereal stubble in lower rainfall environments. A further trial was set up at Pinery in 2013 to investigate whether additional benefits can be achieved by sowing inter-row into stubble reaped with a stripper front (wheat stubble measuring 70cm height and 5.6t/ha in biomass). Stubble treatments were executed pre-sowing, and PBA Blitz⊕ was chosen, having shown the greatest response to stubble management in previous trials. The trial was sown with a knife-point cone seeder on 10 inch (25 cm) row spacings, and rolled immediately post sowing. Significant early grub (mandalotus weevil) damage was noted, particularly in the standing stubble treatments where more than 50% of plants had been defoliated (Table 1). However damage levels were similar in the removed and slashed treatments. This finding highlights the importance of pest protection and vigilant monitoring in retained stubble systems which provide a favourable habitat for a wide range of insects and pests. Final grain yield showed a 58% yield advantage from sowing into slashed stubble compared to removed stubble (Table 1). No benefit was generated by sowing into standing stubble compared to removed stubble, most likely due to the increased levels of damage caused by insect pests in this treatment. As in previous seasons, standing stubble generated a significant improvement in lodging resistance, representing potential harvestability benefits in lentil.

Table 1. Grain yield (t/ha) and lodging score (1-9*) of lentil varieties sown in four stubble management practices at Pinery, South Australia in 2013

Stubble Treatment	Removed	Slashed	Standing 30cm	Standing 60cm	LSD (P<0.05)
^Plant defoliation (%)	23 a	29 a	46 b	57 b	16
Grain yield (t/ha)	1.80 a	2.85 b	1.96 a	1.92 a	0.69
Lodging score	5 a	4.7 a	7.3 b	7.3 b	1.5

** Lodging score: 1= prostrate, 9 = erect, ^% of plants with leaves defoliated due to mandalotus weevil damage*

Field pea

PBA Wharton⁽ᶲ⁾ (OZP0805)

PBA Wharton⁽ᶲ⁾ is a new high yielding 'Kaspa type' field pea. PBA Wharton⁽ᶲ⁾ combines disease resistance to the viruses PSbMV and BLRV and powdery mildew with the same agronomic benefits as Kaspa⁽ᶲ⁾ (e.g. lodging and shattering resistance). PBA Wharton⁽ᶲ⁾ is early to mid season flowering and early maturing (e.g. similar PBA Gunyah⁽ᶲ⁾). It is widely adapted across southern cropping regions of Australia and best suited to districts with a short to medium growing season or those that are prone to powdery mildew and virus diseases (e.g. south east SA). Its grain colour and size is similar to Kaspa⁽ᶲ⁾ but more spherical and smoother. PBA Wharton⁽ᶲ⁾ can be marketed as 'Kaspa type' grain. Seed is available through Seednet.

PBA Coogee⁽ᶲ⁾ (OZP1103)

PBA Coogee⁽ᶲ⁾ is a high yielding conventional (trailing) type dun pea that provides the flexibility of a forage option if frost or drought limit grain yield potential. PBA Coogee⁽ᶲ⁾ has a conventional plant type similar to the variety Parafield but with increased early season growth, more basal branching, longer vines and higher yield. It is a long season variety that flowers mid to late season but pods rapidly and combines resistance to powdery mildew with high tolerance to soil boron and salinity. This variety has moderate resistance to bacterial blight. PBA Coogee⁽ᶲ⁾ produces grain that can be marketed as 'Australian dun type'. Seed is available through Seednet.

Forage peas - a potential new break crop option

In the last 2 years, two varieties (PBA Hayman⁽ᶲ⁾ and PBA Coogee⁽ᶲ⁾) have been released for suitability to 'forage' (hay/silage) or green/brown manuring. PBA Hayman⁽ᶲ⁾ was released as the first Australian forage field pea, while PBA Coogee⁽ᶲ⁾ has been released as a 'dual purpose' (grain or forage) field pea variety. These new pea types provide an alternative to vetch and other break crop options due to the perceived advantages from increased winter dry matter production, improved post-emergent weed control options and opportunistic grain production in low rainfall areas. Work funded by SAGIT (Project S0213) is currently assessing the biomass accumulation and grain yields in comparison with current standards, Kaspa⁽ᶲ⁾ (the predominant grain yield variety in south eastern Australia) and Morgan⁽ᶲ⁾ (a dual purpose field pea variety). Results to date have shown:

- The ideal timing of hay cutting for both maximum biomass production and ease of drying (i.e. before pod set) is likely to be approximately 7-14 days after commencement of flowering (i.e. early pod development prior to grain fill).
- Varieties with later flowering and pod set (e.g. PBA Hayman⁽ᶲ⁾) are likely to be better suited to hay production as this allows maximum vegetative growth prior to cutting, and extends hay cut timing into better (warmer and quicker) drying conditions.
- Kaspa⁽ᶲ⁾, Morgan⁽ᶲ⁾ and PBA Coogee⁽ᶲ⁾ have similar biomass prior to the early pod stage.
- PBA Hayman⁽ᶲ⁾ generally produces greater biomass by the flowering stage than all other varieties (due to its later flowering) and accumulates more biomass during early spring than other varieties (Figure 1).
- Kaspa⁽ᶲ⁾ and PBA Coogee⁽ᶲ⁾ produce significantly higher grain yield than Morgan⁽ᶲ⁾ or PBA Hayman⁽ᶲ⁾.
- PBA Hayman⁽ᶲ⁾ has shown the lowest yield and lowest harvest index, indicating that grain retrieval may be difficult in low rainfall areas. However, due to its lower seed weight (averages 14g/100 seeds compared with 20-25g/100 seeds in other varieties) seed requirements for sowing will be significantly lower.

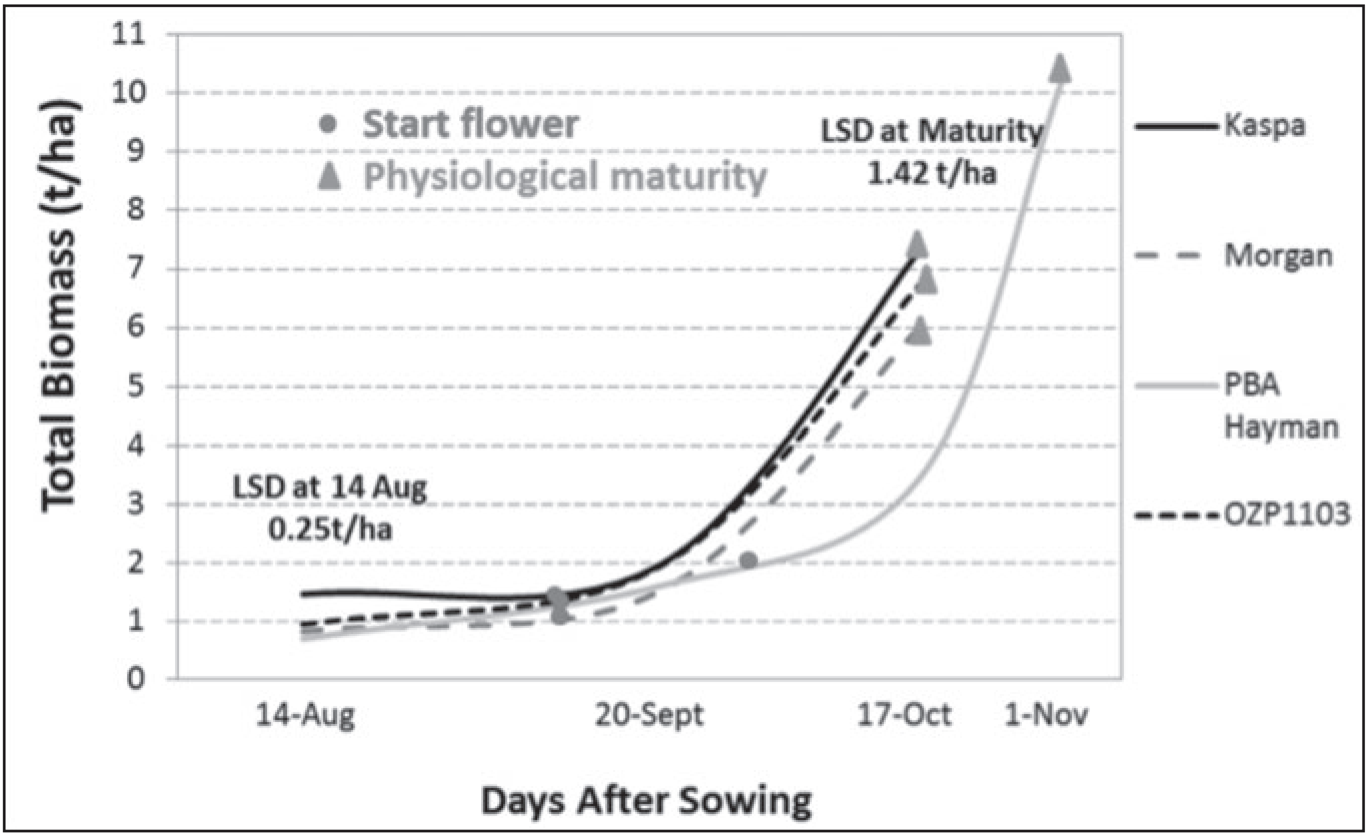

Figure 1. Biomass accumulation of four field pea varieties, showing start of flowering and physiological maturity checkpoints, at Pinery 2012. LSD's are shown for measurements at 14 August and at physiological maturity (Source: Southern Region Pulse Agronomy project (DAV00113)).

Co-mingling of 'Kaspa type' varieties

A number of 'Kaspa type' field pea varieties are now available (Kaspa⟮, PBA Gunyah⟮, PBA Twilight⟮, PBA Wharton⟮) offering the same agronomic advantages as Kaspa⟮ but varying in their flowering and maturing timings and disease resistance profile. Since these can all be marketed together as 'Kaspa type' grain, growers have the opportunity to blend varieties to create a population that potentially provides an extended flowering period compared to a single variety. This strategy may provide risk mitigation against frost and heat events during the vulnerable flowering period, and may also produce a continuously adapting population that may convey a production advantage in the target production area over time. The Southern Pulse Agronomy project has been comparing various blends of Kaspa⟮, PBA Gunyah⟮ and PBA Twilight⟮ at five sites in South Australia; Balaklava, Snowtown, Minnipa, Kadina and Turretfield. Trials in 2012 and 2013 have so far shown that Kaspa⟮ has a yield advantage over earlier maturing varieties and blends in regions with high yield potential (e.g. Turretfield) due to its later maturity and subsequent higher yield potential. At Snowtown in 2013, where PBA Twilight⟮ did not perform well comparable to Kaspa⟮ and PBA Gunyah⟮ due to the favourable season and high yield at this site, a blend containing 50% Kaspa⟮ was able to achieve higher yield than PBA Twilight⟮ alone. In all other trials there was generally no advantage or disadvantage of the variety blends compared to their individual parents.

Chickpea

The chickpea market was supressed significantly in 2013 due to a combination of over-extended buyers (as a result of high prices in 2012) and favourable seasonal conditions for chickpea production in the subcontinent. However chickpea generally performed well in 2013 due to the wet winter and mild (although dry) finish to the season enabling them to achieve close to their yield potential. Chickpea provide significant farming systems benefits, either as a complementary or an alternative break crop to lentils or field pea. Chickpea have the benefit of utilising a different group of pre-emergent herbicide (isoxaflutole, or Balance®, used simultaneously with simazine) than the standard group C chemistry used on lentils; facilitating control of a different spectrum of broadleaf weeds. However, growers should note that chickpea does not compete well with weeds, and are not well suited to crop-topping for weed control, so paddock selection is critical.

PBA Monarch⦶ (CICA0857)

PBA Monarch⦶ is a high yielding medium sized kabuli chickpea. It is particularly well adapted to the shorter season medium rainfall environments of south eastern Australia, due to improved adaptation through earlier maturity compared to Genesis™090, Almaz⦶ and Genesis™Kalkee. PBA Monarch⦶ has a semi spreading plant type and is early flowering and maturing (similar to Genesis™079). It is moderately susceptible (MS) to ascochyta blight (similar to Almaz⦶ and Genesis™ Kalkee but more susceptible than Genesis™ 090). PBA Monarch⦶ has shown a consistent yield advantage of 7-13% over current medium and large seeded kabuli varieties. It has also shown similar yields but larger seed size than the smaller sized Genesis™090. Seed size is predominantly 8-9 mm (larger than Genesis™090 and similar to Almaz⦶). Seed is available through Seednet.

PBA Maiden⦶ (CICA0717)

PBA Maiden⦶ is a large seeded desi chickpea suitable for the medium to low rainfall environments of South Australia, with similar yields to PBA Slasher⦶. It is larger seeded than current southern desi varieties (28% larger than PBA Slasher⦶) with a yellow-tan seed coat, and is well suited to whole seed desi markets such as those in Bangladesh. PBA Maiden⦶ is moderately resistant (MR) to foliar infection by ascochyta blight (equal to PBA Striker⦶). It has a semi-spreading plant type and height similar to PBA Slasher⦶, with early to mid flowering and maturity (earlier than PBA Slasher⦶ but later than PBA Striker⦶). Growers are advised to investigate delivery and marketing options prior to growing this variety due to its unique seed characteristics and marketing potential. Seed is available through Seednet.

Sowing time of chickpea

It is generally recommended that sowing of chickpeas is performed later than other pulses, particularly in favourable areas, due to poor pod set in cool weather (winter) conditions and excessive lodging in favourable regions and seasons where vegetative growth is high. However, in recent seasons with low disease pressure, mild conditions during flowering, and lower than average spring rainfall, earlier sowings (generally mid May) have achieved equal or higher yields to later sowings (early-mid June), provided disease has been managed (Figure 2). The late maturing kabuli variety Genesis™ Kalkee was the only variety not to show a sowing time response in 2013. Despite these findings the risks associated with early sowing chickpeas must be considered, and sowing at the end of the sowing program is still recommended, particularly in favourable areas.

Faba bean

The overall yield of faba beans was quite varied throughout South Australia, largely due to the dry conditions at the end of the growing season. Good winter rains set the trials up for high yield potential and NVT sites in favourable areas (Tarlee, Maitland and Minlaton) achieved in excess of 3t/ha. Overcast conditions and low temperatures during late winter and early spring impacted on podding and there were numerous reports of poor pod set in the lower canopy. The high humidity and vigorous winter growth also increased chocolate spot intensity, and multiple fungicide sprays were required to control

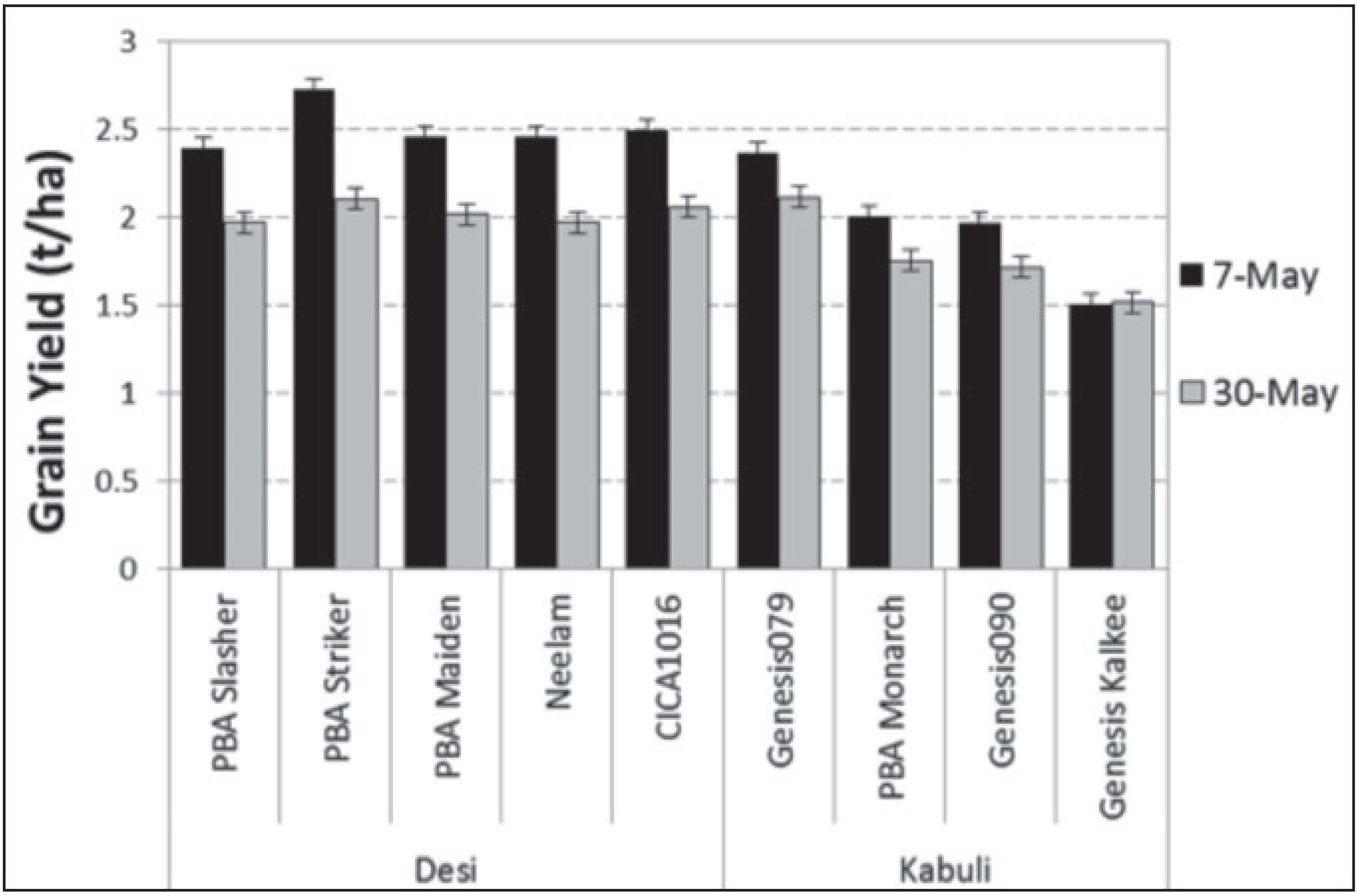

Figure 2. Effect of sowing time on grain yield (t/ha) of chickpea varieties at Pinery, 2013 (Source: Southern Region Pulse Agronomy project (DAV00113)).

this disease. Ascochyta blight pressure was higher in 2013 than in previous seasons, and a change in resistance of one isolate resulted in increased ascochyta blight infection in Farah⁽ᵖ⁾ and PBA Rana⁽ᵖ⁾. Symptoms indicative of Pea Seedborne Mosaic Virus (PSbMV) appeared on seed from a number of faba bean crops and in severe cases resulted in downgrading of quality. For further information on pulse diseases in 2013 refer to article by Jenny Davidson, SARDI, in these proceedings.

There was little variation in yield among current faba bean varieties across trials in South Australia, and in particular Fiesta VF and Farah⁽ᵖ⁾ were very similar. The average yield of Nura⁽ᵖ⁾ was slightly less than Fiesta VF and Farah⁽ᵖ⁾, while PBA Rana⁽ᵖ⁾ averaged 3-4% less than other varieties across all trials. In view of the small variation in yield, factors such as disease resistance, herbicide tolerance, seed quality and access to particular markets should be considered when selecting varieties

Potential new release - AF05069-2⁽ᵖ⁾

This breeding line has very good yield (generally 8-10% greater than current varieties), wide adaptation and very good ascochyta resistance. Resistance to other diseases is equal to or better than current varieties. It is a moderately late flowering type, similar to Nura⁽ᵖ⁾ and PBA Rana⁽ᵖ⁾, and has improved standing ability compared to Farah⁽ᵖ⁾. Seed is comparable in size and colour to Fiesta and Farah⁽ᵖ⁾. A release in 2014 for cultivation in 2015 is likely.

Improving weed management in faba beans – Dili Mao, SARDI

A five year GRDC funded project led by SARDI in conjunction with the University of Adelaide commenced in July 2013. It follows on from the project DAS00107, which successfully developed a number of faba bean and lentil lines with improved tolerance to novel herbicides, and aims to continue this work along with expanding it into chickpea.

Most recently, controlled environment growth room dose response studies have confirmed high levels of imazapyr tolerance in three mutated faba bean lines compared with the Nura⁽ᴾ⁾ control (Figure 3). The three lines were confirmed as having different mutation events which all confer the ALS (Group B) herbicide tolerance. All lines incurred no visible damage to Imazapyr at rates of 3L/ha and lower while the Nura⁽ᴾ⁾ control showed high levels of damage, and eventually died at the lowest rate (0.75L/ha).

These lines have been incorporated into the PBA faba bean breeding program and the herbicide tolerance has been confirmed in cross and backcross populations with elite breeding material. Crossing for tolerances to multiple herbicide groups (Group B and Group C) has also been initiated in both lentils and faba bean. This year the project will begin field validation of the most promising herbicide tolerant faba bean (Imazapyr) and lentil (metribuzin) lines as well as investigating methods for rapidly developing lines with tolerance to multiple herbicide groups. It will also begin the process of developing desi and kabuli chickpeas lines with novel herbicide tolerance through conventional mutagenesis techniques. *(For more information contact Dili Mao, SARDI at* ***dili.mao.sa.gov.au****)*.

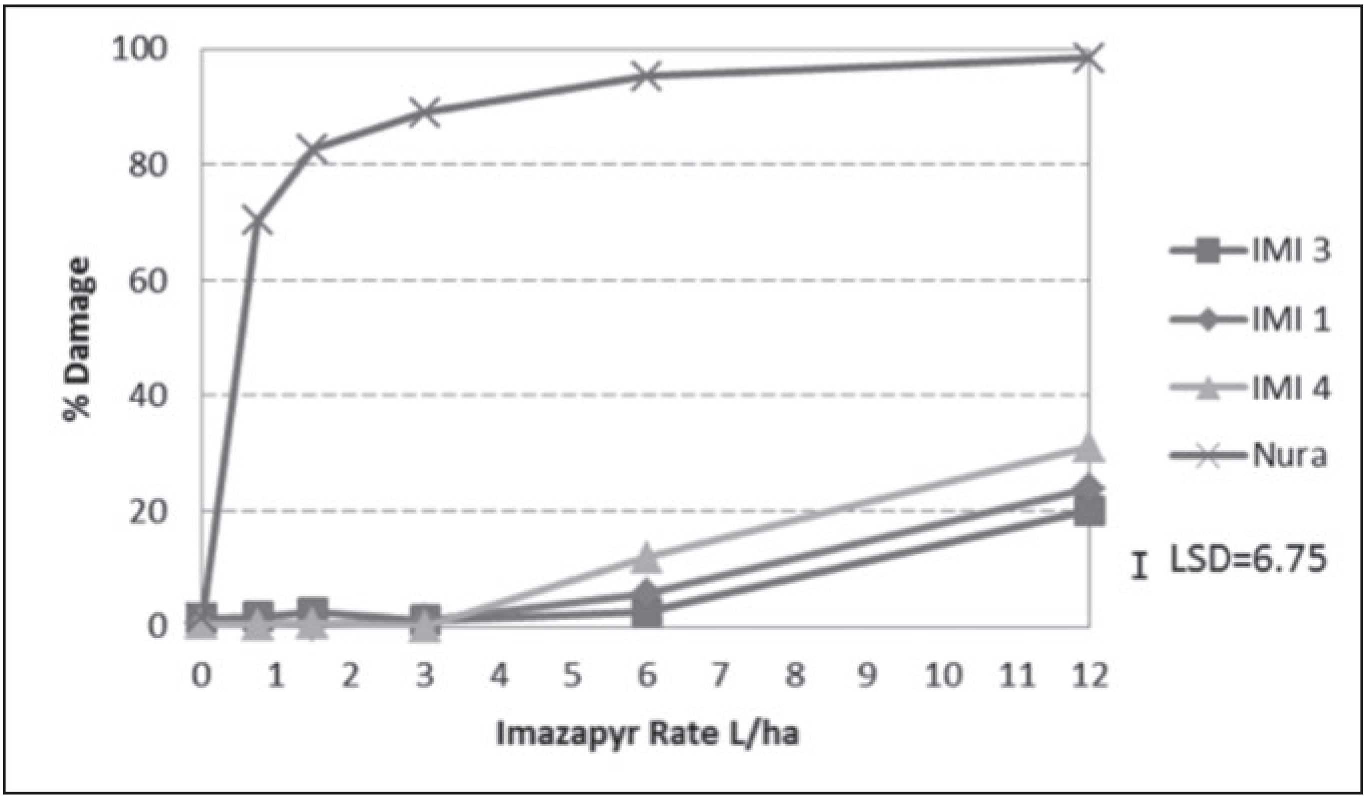

Figure 3. Effect of post-emergent Imazapyr herbicide on plant damage level (% plant area necrotic) of three induced mutant faba bean lines and the control cultivar Nura grown in controlled environment conditions (Source: Improving weed management in pulses (DAS00131)).

Lupin

The performance of lupins was variable in 2013, with some growers disappointed with yields despite well grown crops and others receiving above average returns. Newly released variety PBA Barlock⊕ performed well in NVT and breeding trials around SA in 2013, and was amongst the highest yielding at most sites. Spring conditions brought about good conditions for disease in lupins in 2013, with higher than normal levels of Bean Yellow Mosaic Virus (causing black pod syndrome) and Phomopsis (with potential to cause lupinosis) seen in trials and commercial crops. PBA Barlock⊕ showed good resistance to BYMV, which helps explain its higher yield at some sites (Wanilla).

PBA Barlock⊕ (WALAN2325)

PBA Barlock⊕ is a high yielding Australian sweet lupin variety which provides a significant yield improvement in most regions of New South Wales, Victoria and South Australia. PBA Barlock⊕ is a considerable improvement in metribuzin tolerance over the varieties Tanjil⊕ and Wonga⊕ and will allow growers to use metribuzin as an option for controlling weeds within the lupin crop. PBA Barlock⊕ is early flowering and maturing, is moderately resistant to lodging in high rainfall regions, and shows improved pod shatter resistance compared to Tanjil⊕ and Coromup⊕.

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Notes

Diseases in pulse crops during 2013

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GRDC project codes: DAS0139, DAV00113, UA00097

Keywords

ascochyta blight, resistance breakdown, botrytis, fungicide strategies, Pea Seed borne Mosaic Virus, lupinosis

Take home messages

- **Nipper⦶ lentils and PBA Rana⦶ faba beans require additional fungicide sprays due to ascochyta resistance breakdown.**
- **Ascochyta blight in chickpea cultivars and breeding line; reactions range from Resistant to MR-MS, requiring different spray strategies.**
- **Botrytis grey mould and chocolate spot were high risk in 2013 due to heavy canopies and wet winter. Strategic spray programs controlled most of the disease.**
- **Sclerotinia was widespread in many pulse and canola crops. Sclerotes in grain can lead to rejection at silo. Sclerotes are not toxic to stock.**
- **Pea Seed borne Mosaic Virus was widespread in faba beans in 2013. Seed to seedling transmission is believed to be low in faba beans but growers should be cautious and source seed with a low level of virus. Research is continuing to confirm the transmission rates in varieties, particularly Nura⦶.**
- **Lupin producers must be aware of the high risk of lupinosis when grazing lupin stubbles this year.**

Ascochyta blight

Infection of ascochyta blight on Nipper⁽ᵖ⁾ lentil in commercial crops and in trials was widespread across South Australia and Victoria in 2013, confirming the partial breakdown of resistance in this cultivar, which was first observed in 2010. Lesions on Nipper⁽ᵖ⁾ were more aggressive this season than in previous years, indicating the virulent isolates have crossed with adapted isolates and improved their fitness. Ascochyta blight scores on Nipper⁽ᵖ⁾ were similar to Nugget in most agronomy or breeding trials (Figure 1). In research funded by SAGIT ('Resistance monitoring of ascochyta blight in lentils') a number of *Ascochyta lentis* isolates collected from these trials were tested in controlled conditions and found to be highly aggressive on Nipper⁽ᵖ⁾. This indicates that a similar disease control program to Nugget should now apply to Nipper⁽ᵖ⁾ i.e. spray at podding ahead of a rain front to prevent pod infection. At two of these trials PBA Jumbo⁽ᵖ⁾ had similar disease levels to NipperA and Nugget, while PBA HeraldXT⁽ᵖ⁾, PBA Ace⁽ᵖ⁾, PBA Bolt⁽ᵖ⁾, PBA HurricaneXT⁽ᵖ⁾ and PBA Blitz⁽ᵖ⁾ maintained resistance at all three sites.

In the SAGIT funded project, lentil stubble infested with ascochyta blight had been collected in December 2012 from five commercial crops (PBA Flash⁽ᵖ⁾, Nipper⁽ᵖ⁾ and Nugget). This stubble was incubated at SARDI in external conditions, next to pots containing seedlings of eight different lentil lines i.e. resistant sources Northfield, Indianhead and ILL7537; commercial cultivars Nipper⁽ᵖ⁾, Nugget, PBA Flash⁽ᵖ⁾ and PBA HeraldXT⁽ᵖ⁾; and a susceptible check, Cumra. For a four week period starting 26 July 2013, lesions that developed on these seedlings were recorded and collected for storage and further research. While the majority of lesions developed on the susceptible lines Cumra and PBA Flash⁽ᵖ⁾, a small number also developed on each of the resistant sources and on PBA HeraldXT⁽ᵖ⁾ (Figure 2). These results demonstrate that virulent isolates able to overcome all resistant sources already exist in the A. lentis population in South Australia and the resistance in PBA HeraldXT⁽ᵖ⁾ and similar lines is at risk. Further work is continuing in the SAGIT funded project this year to assess all current NVT lentil entries against the Nipper⁽ᵖ⁾ virulent isolates.

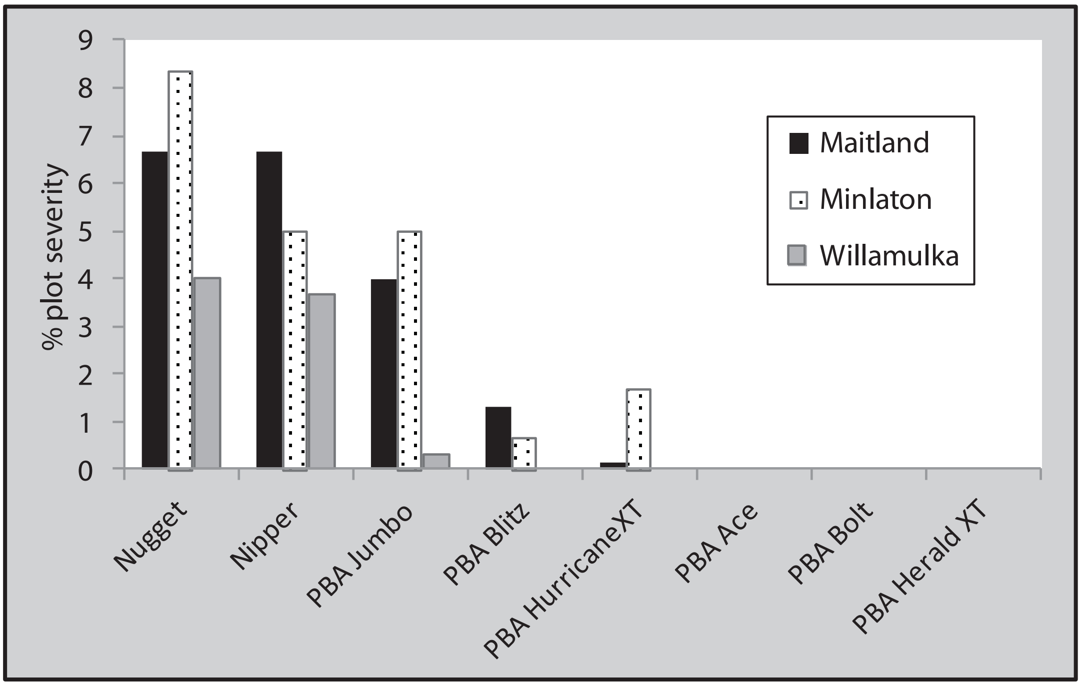

Figure 1. Ascochyta blight scores in lentil NVT trials 2013; lsd = 2.02.

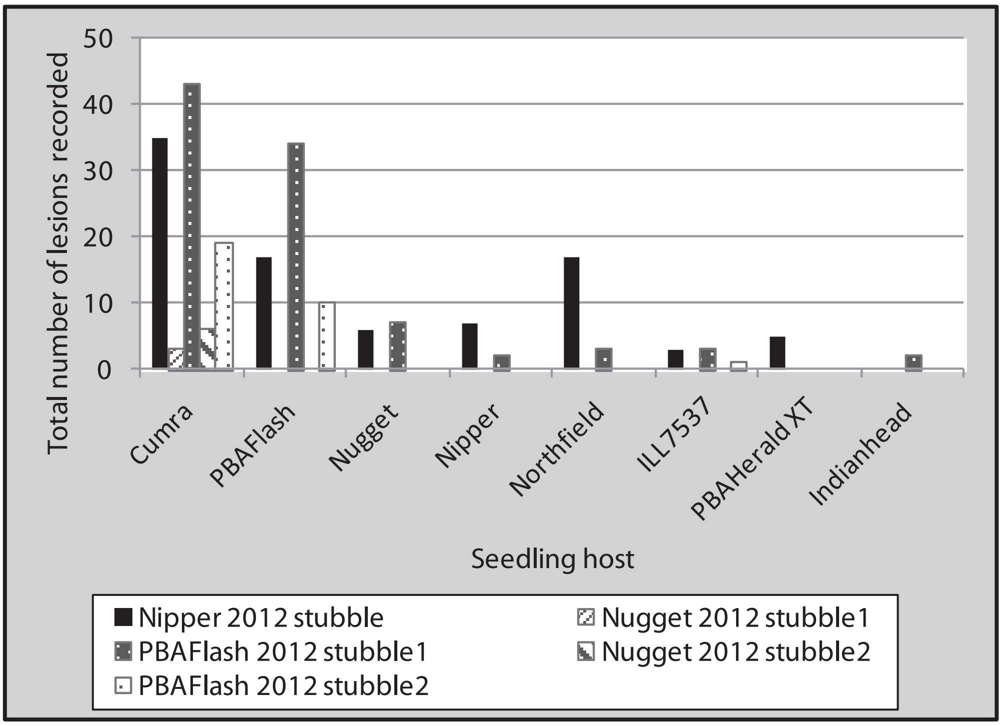

Figure 2. Number of ascochyta lesions recorded on lentil hosts grown adjacent to lentil stubble infested with *A. lentis*.

Faba beans

Changes in the reaction of ascochyta blight on previously resistant lines of faba bean were observed in faba bean breeding trials in the Lower North region of South Australia in 2013 and in a commercial crop from Poison Gate in NSW in 2012. Isolates of *A. fabae* from these sites were tested in greenhouse conditions at SARDI. The Poison Gate isolate from NSW was able to infect the previously resistant PBA Rana⊕ and a number of breeding lines, indicating virulence against one resistance gene. The isolates from South Australia were able to infect PBA Rana⊕ as well as Farah⊕ and a range of other breeding lines, confirming that a second resistance gene has been compromised (Table 1). Further research is being conducted to identify resistance to these virulent isolates. Management of ascochyta blight on PBA Rana⊕ now involves additional fungicide sprays particularly during podding to prevent pod infection and seed staining. Further research will investigate the benefit of a vegetative spray for ascochyta blight on PBA Rana⊕.

Chickpeas

The Southern Region Pulse Agronomy project conducted fungicide trials for ascochyta blight on chickpea at Kingsford in 2013; plots were artificially inoculated with stubble in July. In these trials, there was a strong correlation between the ascochyta blight score and % yield loss, compared to plots with fortnightly sprays of fungicide (Figure 3). Genesis™ Kalkee, PBA Striker⊕ and PBA Monarch⊕ showed greatest yield loss (≥30%) in plots that were unsprayed or sprayed only at podding. A three spray strategy (strategic treatment) reduced yield loss to 15% in these lines compared to fortnightly sprays. PBA Slasher⊕ and PBA Maiden⊕ had a similar yield loss (10-15%) in all three treatments. Hence under these conditions a podding spray was sufficient to control the disease, although the current management practice for PBA Maiden⊕ is a spray at 6-8 weeks as well as the podding spray. Genesis™090 showed no yield loss, but the presence of lesions on foliage and stems indicates a podding spray is a good insurance against potential pod and seed infection.

Table 1. Pathogenicity of a standard isolate and Poison Gate isolate of *A. fabae* in a glasshouse test on 17 known resistant and 4 known susceptible faba bean genotypes in Australian germplasm, and ascochyta scores at two field trials in SA. Potential resistant sources that remain stable in all assessments are marked. Shaded squared indicate susceptible reactions

Line	Ascochyta blight severity - stem lesions (%)				
	Glasshouse- A. fabae Isolate		Field trial - South Australia		Potential resistant source in pedigree
	Standard	Poison Gate	Saddleworth	Tarlee	
Acc 1322	0.00	0.00	-	-	1322
Acc 622-1	0.00	0.00	-	-	622
AF06125	0.00	0.67	1.67	0.00	970, S95005/5, 622, 483
AF09169	0.00	0.83	40.00	13.33	IX38/1 -10AR, 1269, 483
AF09167	0.00	1.79	26.67	13.33	IX38/1 -10AR, 622
AF09059	0.00	2.13	8.33	10.00	683, 483, 970, S95005/5
AF07125	0.00	3.47	30.00	23.33	1108, 683, 483
AF08161	0.00	4.35	63.33	30.00	611, 622
AF05095 -1	0.00	5.52	16.67	3.33	920/3, 483
AF05069 -2	0.00	6.58	1.67	0.00	611, 722, 622, 483
Acc 970	0.00	10.93	-	-	970
PBA Rana	0.00	11.21	21.67	6.67	611
Acc 1269*483/6	0.00	24.42	-	-	1269, 483
AF09096	0.00	40.17	83.33	33.33	S95005, 483, 611
AF04053	0.00	41.25	81.67	35.00	683, 483
Nura	0.75	0.60	13.33	8.33	622
Farah	1.71	8.33	50.00	31.67	483 (heterogenic R)
Fiesta	5.75	12.50	73.33	50.00	483 (heterogenic S)
Doza	22.52	17.29	83.33	-	
PBA Warda	24.37	11.16	70.00	-	
Icarus -3	28.54	35.21	-	-	
Legend	F	MR/M	MS	S	

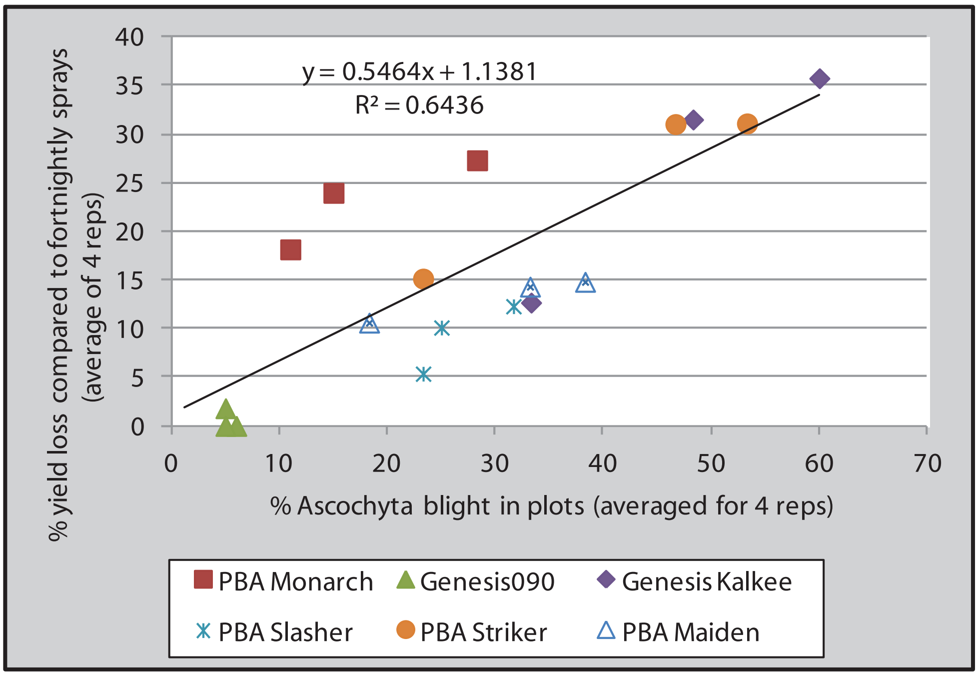

Figure 3. Relationship between % yield loss (compared to fortnightly sprays) and ascochyta blight severity in fungicide trial at Kingsford, 2013.

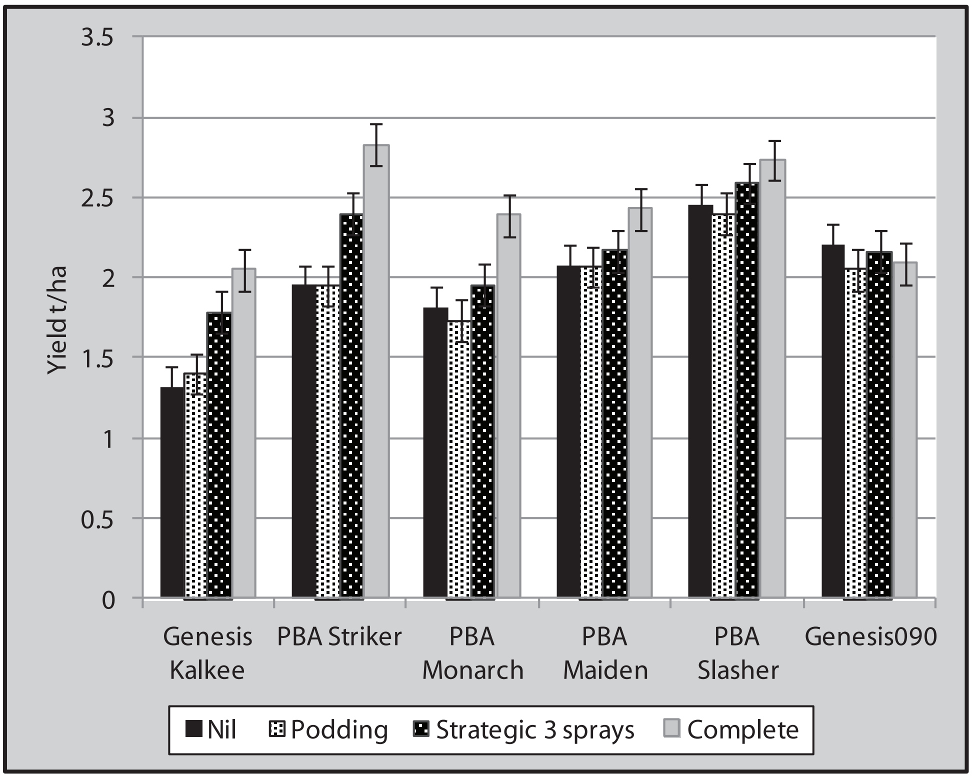

Figure 4. Yield of chickpea lines in ascochyta blight fungicide trial at Kingsford 2013.

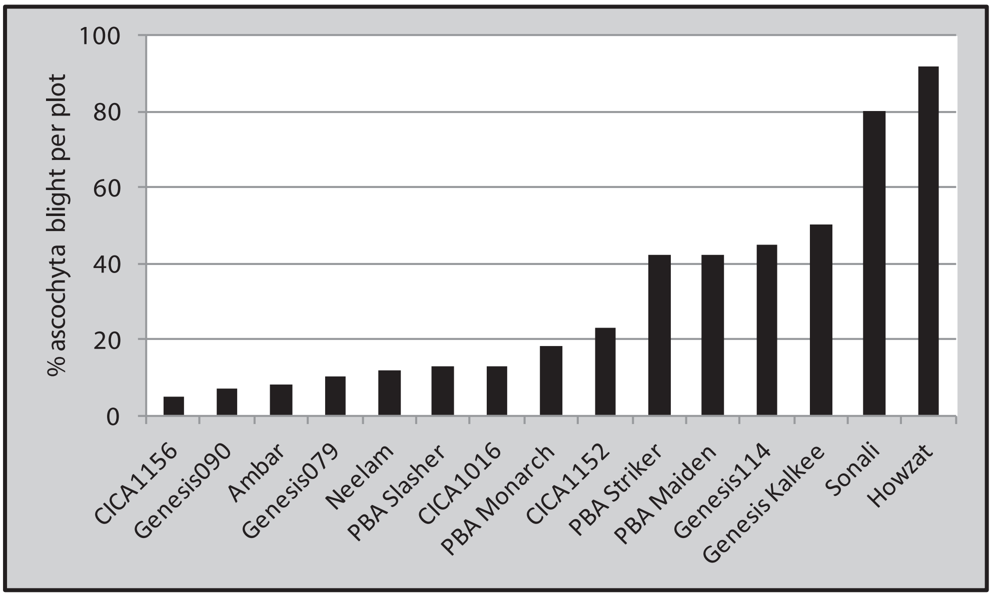

Figure 5. % Ascochyta blight per plot in chickpea lines at Kingsford Sept 24 2013.

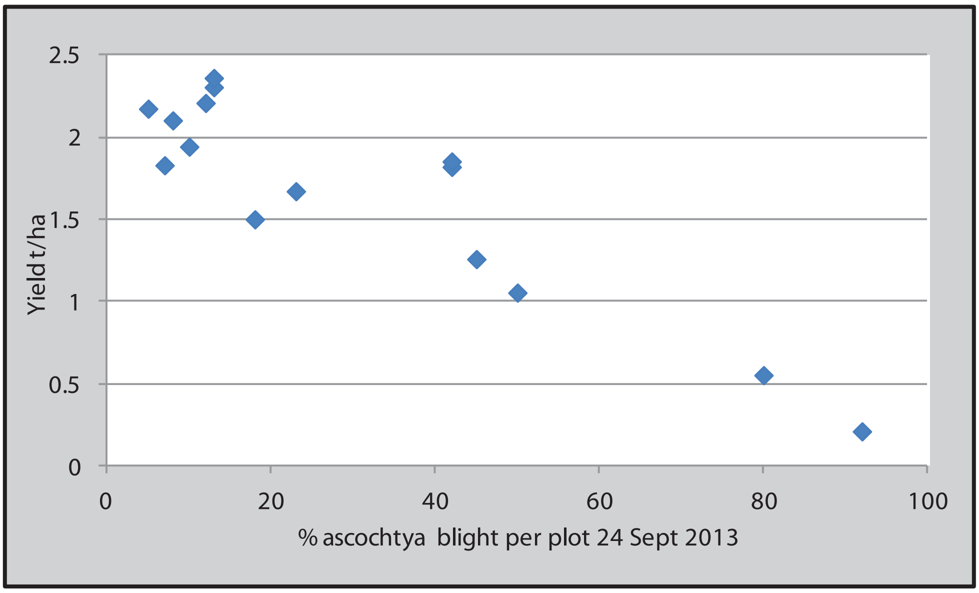

Figure 6. Relationship between ascochyta blight rated on 24 September and final yield in chickpea trial.

Fifteen chickpea cultivars and breeding lines were scored for reaction to ascochyta blight in a second trial at Kingsford in 2013 (Figure 5). Resistant reactions were noted in CICA1156 and CICA1016, as well as Ambar, Neelam⏀, Genesis™090, Genesis™079 and PBA Slasher⏀. As with the first trial there was a good correlation between the ascochyta scores and yield.

Blackspot in field peas

Blackspot Manager forecasted that field pea crops sown during the second and third week of May in 2013 were at risk of blackspot in many areas. This is the peak sowing timing for many field pea crops in South Australia and as a result there were a number of reports of high blackspot infection in pea crops this season. The heavy winter rains further increased this disease to a high level in some crops.

Questions were raised about late (spring) sprays of mancozeb in field peas to control blackspot. This is less likely to be economic if no earlier sprays have been applied. The most economic strategy for blackspot includes a thiram based seed dressing (eg. P-Pickel T®) followed by mancozeb at 9 nodes (canopy closure) and a second mancozeb spray at early flowering. This strategy is likely to only be economic in field pea crops with a potential yield of 2 t/ha or more.

Botrytis and sclerotinia diseases

Prolific early crop canopy development occurred in a number of pulse crops across South Australia due to high winter rainfall and warmer than average May and June temperatures in 2013. Canopy closure sprays for botrytis diseases (chocolate spot and botrytis grey mould [BGM]) were initiated in these crops in late July- early August, which is 3-4 weeks earlier than normal. Consequently multiple sprays were required later in the season to maintain disease control. The dry spring assisted in keeping these diseases under control. PBA Ace⏀ had a moderately resistant reaction to BGM in trials in the last season while PBA Bolt⏀ and PBA HurricaneXT⏀ are moderately susceptible and required additional fungicide sprays after the canopy closure spray, particularly when conditions are moist or humid.

The wet winter also encouraged sclerotinia in many pulse crops and in some canola and lupin crops during August and September, with BGM and sclerotinia occurring together in many cases. BGM severity was increased where wild tares acted as disease foci, and sclerotinia appeared worse where canola had been grown recently in the rotation. Sclerotes were observed in some grain samples, particularly lupins and canola. If contaminated grain is used as seed for cropping, the sclerotes will transfer the disease into the new crop. Grain contaminated with sclerotes is safe to use for stock feed.

Extensive rainfall also encouraged white leaf spot in some canola crops during August and September. The symptoms are similar to blackleg lesions on the leaves, but without the pycnidial black spotting in the centre. White leaf spot rarely results in yield loss.

Downy mildew trials in field peas

Treatments for downy mildew in field pea were tested in a trial at Kybunga in the mid north of SA. This included ApronXL®, and three other seed treatments, and a foliar treatment of phosphorous acid (Agri-Fos 600), at 3.5 L/ha, applied at three different timings. No differences in yield were observed between treated and untreated plots suggesting the level of disease (leaf infection up to 25% per plant on August 8th), was insufficient to cause a yield loss last season. No seedling death or stunting was noted in this trial. Downy mildew is most damaging when young seedlings are emerging, resulting in death of seedlings and stunted growth. A metalaxyl seed dressing is recommended in at risk paddocks to prevent this early damage.

PSbMV in faba beans

Staining from Pea Seedborne Mosaic Virus was widely detected in faba bean grain harvested across South Australia and Victoria this season. Early results from breeding trials suggest that Nura⁽ᵈ⁾ had the highest rate of infection compared to other varieties. This virus is transmitted between plants and crops by aphids, most commonly by green peach aphid (*Myzus persicae*), but also by the oat/wheat aphid (*Rhopalosiphum padi*). The latter was abundant in cereal crops this year and may have been responsible for virus transfer.

The source of the virus may be any pulse crop or pulse pasture but not cereals nor canola. Often the source of PSbMV is from neighbouring field pea crops, especially Kaspa⁽ᵈ⁾ which is highly susceptible. It is unclear why the PSbMV level appears to be low in field pea this season.

The transmission of this virus from seed to seedling is thought to be low in faba beans (<1%), which means the grain can be used to sow the next year's crop with low risk of infection. Further studies will be conducted to confirm the low rate of transmission in different faba bean varieties, especially Nura⁽ᵈ⁾. However note that if using infected field peas, the transmission may be 100% i.e. every infected seed may produce an infected seedling.

Growers who are concerned about virus transfer can reduce the risk by;

- sourcing seed from unaffected area or region or use seed from a less affected area of the crop,
- grading hard to remove smaller grain, which are more likely to be infected,
- using imidacloprid (Gaucho®) seed dressing to prevent aphids colonising the seedling crop in autumn – early winter, and spreading more virus,
- planting into a stubble to reduce aphid landings during autumn- early winter,
- avoiding planting faba beans adjacent to field peas especially Kaspa⁽ᵈ⁾ which may be a reservoir for PSbMV; and
- if aphids colonise crops, spray in spring before the aphids take flight.

Other staining issues have also been recorded on faba bean grain, leading to downgrading or rejection at the silo. These are a mixture of ascochyta blight (*Ascochyta fabae*), chocolate spot (*Botrytis fabae*), weather staining and possibly frost damage. Grain with more than 5% infection of *Ascochyta fabae* and/or more than 10% infection of *Botrytis fabae* is not recommended for sowing.

Lupinosis risk in lupin stubble

Lupin producers must be aware of the high risk of grazing lupin stubbles this year. Lupinosis is caused by toxins produced by the fungus *Phomopsis* l*eptostromiformis* (synonym *Diaporthe toxica*). This fungus grows saprophytically in mature lupin stems. Varietal resistance will slow the growth of the fungus, but won't stop it, so under moist and humid conditions even the most resistant variety currently available can produce toxins with the potential to kill stock. Conditions towards the end of the 2013 growing season were ideal for the development of the Phomopsis fungus. Lupin growers wanting to graze stubbles are advised to inspect the stubble for symptoms. These usually appear on senescing or dry lupin stems as dark purplish brown lesions which bleach with age and contain black fruiting bodies. Lesions can develop on pods, causing the surface of green pods to become 'slimy' and mature pods to be shrivelled with dark discolouration.

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Plant growth regulators in broad acre crops

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GRDC project code: UT00028

Keywords

plant growth regulators, wheat, lodging, yield.

Take home messages

- **Plant growth regulators are generally accepted to reduce plant height in grain cereals when applied at the appropriate stage of development; improvement in grain yield tends to be inconsistent.**
- **A survey of 142 Australian agronomists found that 20 per cent recommend the use of plant growth regulators in crop management of wheat, mainly due to improved lodging resistance followed by height reduction and improved yield.**
- **Reasons why agronomists do not recommend plant growth regulator use in the crops they manage included that they were 'not needed' or unsuited to their region.**
- **Application of plant growth regulator with no change in yield from, for example, a 2.38 million ha area (representing 70 per cent of the HRZ) would lead to a cost of around $70 million. In contrast, there would be a net benefit of around $35 million and $138 million for a 5 and 10 per cent change in grain yield in the HRZ respectively.**

This paper provides a brief overview of current plant growth regulators (PGRs) and reports on selected results of a survey of Australian agronomist's use of PGRs in wheat production.

Plant growth regulators

Currently, the four main classes of PGRs used in Australia include ethephon (ETH) and other compounds that disable the gibberellic pathway at different stages of biosynthesis. These include onium-types (chlormequat, CCC) and second and third generation PGRs the triazoles (such as tebuconazole (TEB)) and trinexapac-ethyl (TE), respectively. Of these, only CCC and TEB are registered for use in cereals and none for canola. TE is expected to be registered for use in cereals in Australia by 2015.

The most widely evidenced mode of action in the scientific literature for PGRs is in the reduction of plant height when these are applied at early stem elongation in cereals (Berry *et al.* 2004) or rosette formation in canola. Shorter plant height increases crop resistance to lodging and can improve harvestability and possibly grain quality if lodging is associated with increased sprouting. In some instances PGRs have been linked to an increase in stem strength (Tripathi *et al.* 2004) and number of roots (Emam and Shekoofa 2009).

The effect of PGRs on grain yield is inconsistent and reflects the complex interaction between crop species and variety, the type, rate and timing of PGR application with respect to plant phenology and environmental conditions. Some improvement in yield has been reported in response to PGRs used on wheat but generally not for either barley or canola, although there are some exceptions (Berry and Spink 2009).

Survey

To better understand current usage of PGRs in grain crops, we conducted a broad ranging telephone survey of agronomists working for eight major rural supply companies across Australian grain growing regions. In total, 142 agronomists were interviewed by telephone. Participants provided information relating to PGR use on the range of crops grown in their area, rates of application, reasons for use, response of crops/effectiveness and a variety of other variables. The survey was approved by the UTAS Human Research Ethics Committee (reference number: H0013500).

Why do agronomists recommend PGR use?

The sample of agronomists adequately represented the diversity of both crops types and property sizes. This paper will focus on wheat, which was the main crop managed by the agronomists who participated in the survey.

Of the 142 agronomists who participated in the survey, 29 (20 per cent) reported recommending PGRs for application in wheat. The extent of use was low for these participants; 66 per cent of respondents recommended PGR use on wheat for less than five per cent of the hectares they managed, and only 10 per cent of respondents recommended PGRs for greater than 40 per cent of hectares under their management.

The agronomists who recommended PGRs generally reported higher yields for wheat (4.0 t/ha) than those who did not recommend PGRs (3.1 t/ha), however, this is likely to be related to the region or rainfall zone the agronomists were working in. The larger biomass production associated with increased yield requires greater crop inputs and PGRs are well-recognised as one management strategy to manipulate canopy size to reduce lodging (Pinthus 1973; Berry *et al.* 2000; Berry and Spink 2009).The majority of respondents (69 per cent) recommended that growers apply a combination of PGRs.

The majority of respondents (86 per cent) reported only one application of PGRs per season and 10 per cent of respondents reported two applications per season. There was some variation in the timing of PGR application (Table 1), however most agronomists (76 per cent) applied PGR at the early stem elongation stage.

Table 1. Growth stages at which PGRs are generally recommended for wheat

Growth stage	Number of respondents (%)
Booting	1 (3%)
Early stem elongation	22 (76%)
Late stem elongation	2 (7%)
Late tillering	3 (10%)
Total	29 (100%)

Benefits of plant growth regulator use

When agronomists participating in the survey were asked to explain the benefits that come from using PGRs in wheat, effects on lodging and the related theme of height reduction were frequently reported (Figure 1). Yield was also reported as an important benefit but not to the extent that it had been used for justifying a recommendation of PGR use in this crop.

Harvestability and straw strength/thickness were also nominated as important observed benefits. These two themes appeared related to each other and may also have been related to the observed benefit of height reduction, with those three themes all indicating a more compact growth habit and improved harvestability.

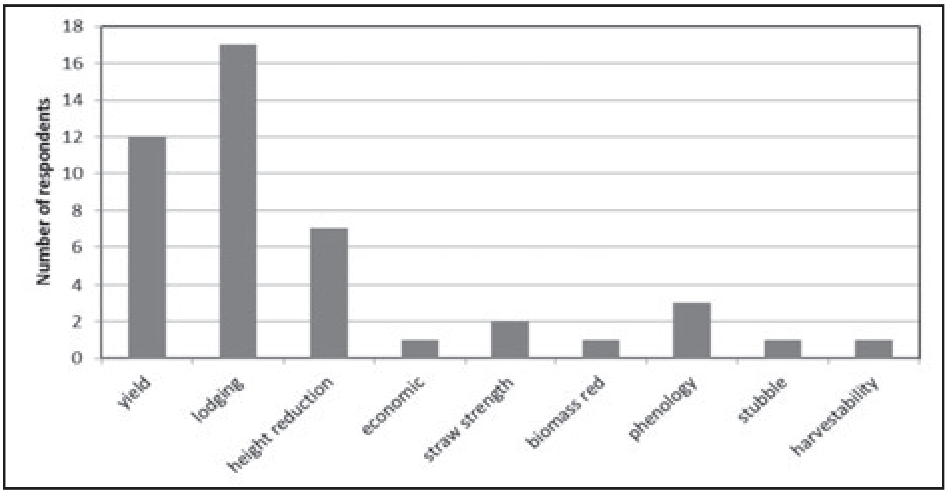

Figure 1. Benefits described by agronomists from the use of PGRs in wheat.

Why do agronomists not recommend plant growth regulator use in wheat?

Those agronomists who did not recommend PGRs for application to wheat provided insights into the perception and experience of those who had either tried these products previously or were unconvinced by the evidence of their efficacy (Figure 2).

The largest theme to emerge was that PGRs were not needed in the area the agronomist managed. This was usually related to typical yields for the region or rainfall zone that the agronomist worked in, with low yield areas most often associated with the theme of 'not needed'. The related theme of 'not suitable in the environment or area' was also mentioned by many of the respondents. An important theme to emerge from this question was an economic one where respondents said that the application of PGRs to the crops they managed did not provide a justifiable return on the cost of application. Related to this was the theme that the science or evidence of the effectiveness of PGRs was perceived to be weak or lacking.

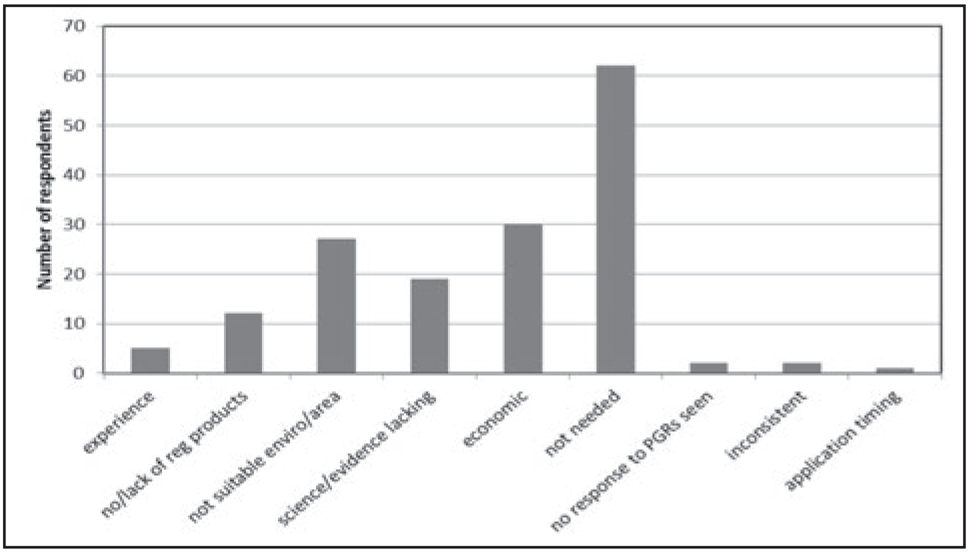

Figure 2. Agronomists' reasons for not recommending PGR use in wheat.

Economic analysis

An understanding of the potential economic contribution of PGRs to the grains industry can be obtained from the simple analysis in Table 2. The analysis is based on the potential yield gains from the application of PGR to wheat in the high rainfall zone.

The most certain economic benefit of PGRs is a reduction in plant height and an associated improvement in lodging resistance, which leads to improved harvestability. This would reduce the loss of grain through shattering or poor quality. Indirect benefits include a potentially reduced cost of harvesting, both by reducing the effort required to maximise the harvest of crops with a high incidence of lodging and also through reduced investment in harvesting technologies to reduce grain losses. PGRs are also likely to improve dry-matter partitioning to grain, particularly in the high rainfall zone where the combination of higher rainfall and higher input can lead to proportionally greater production of vegetative matter.

As an example, the area planted to wheat in high rainfall zone is around 2.38 million ha, estimated from ABS production statistics as 70 per cent of the total area of the high rainfall zone (3.4 million ha) (ABS 2011). Average yields are around 4 t/ha (Sylvester-Bradley et al. 2012), which puts total wheat production from the high rainfall zone at around 9.52 million tonnes.

The analysis in Table 2 shows the potential economic returns to the grains industry if PGRs return 0 per cent, 5 per cent and 10 per cent increases in grain yields. A long term average wheat price of $220 per tonne is assumed, along with the current price of the most expensive PGR (Moddus, $770 for 5 litres), which equates to $30 per hectare when applied at the recommended rate of 1.2 L/ha.

As could be expected, application of PGR with no change in yield from a 2.38 million ha area would lead to a cost of around $70 million. In contrast, there was a net benefit of around $35 million and $138 million for a five and 10 per cent change in grain yield in the HRZ.

Table 2. Economic analyses for return on investment for use of the PGR Moddus for a nil, 5 or 10 per cent increase in grain yield in the HRZ. Assumptions are described in the text

Item	Base line	Change in grain yield		
		0%	+5%	+10%
Area (Mha)	2.38	2.38	2.38	2.38
Yield (t/ha)	4.00	4.00	4.20	4.40
Total yield (Mt)	9.52	9.52	10.00	10.47
Return at $220/t ($M)	2094.4	2094.4	2200.0	2303.4
Cost at $30/ha ($M)	0	71.4	71.4	71.4
Net Return ($M)	2094.4	2023.0	2128.6	2232.0
Net Benefit ($M)	0	-71.4	34.2	137.6

Acknowledgements

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Notes

Feeding the dragon – modernisation of China's food industry and what it means to the Australian grains industry

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For information regarding this topic, please access the full report at http://www.anzbusiness.com/content/dam/anz-superregional/AgricultureInsightsChinaFood.pdf

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Notes

Blackleg pod infection, resistance group monitoring and sclerotinia

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GRDC project codes: UM0051, MGP0003, DAN00177

Keywords

canola, blackleg, disease management, resistance groups, pod infection, sclerotinia

Take home messages

- **Blackleg pod infection was severe in some locations in 2013.**
- **Pod infection can cause significant yield loss.**
- **Group E cultivars have developed low levels of stem canker on the Eyre Peninsula.**
- **Consult the Blackleg Management Guide for details of resistance groups.**
- **Regional monitoring results for each resistance group are available on the NVT online website.**
- **Sclerotinia was prevalent in NSW, WA and north eastern Vic.**
- **Sclerotinia was more severe where extended wetness and warm weather coincided during flowering.**
- **Weigh up yield potential, disease risk and costs of fungicide application when deciding to apply a foliar fungicide.**

Blackleg pod and seed infection

In 2013 blackleg pod infection was observed in all monitored regions of South Australia. Pod infection will result in seed infection, infected seeds may die and shrivel and/or cause pod shatter; reducing yield. Seed retained from infected pod will have reduced germination and may result in seedling blight.

Pod infection was assessed on six cultivars which were present at each site and chosen as they represent the resistance groups used in blackleg management (groups A, B, C, D, E and G). Plants were assessed by counting all pods on randomly selected plants and then counting the number of pod lesions to determine the percentage of infected pods per plant (Table 1.).

Cultivar and regional effects were recorded with groups D, E and G showing no or very low pod infection. Although pod infection was not shown to be correlated to stem canker infection it was clearly evident that in cultivars which have effective seedling resistance (such as group D, E and G), very little, if any pod infection was observed compared to those reliant on adult plants' resistance (groups A, B and C). These data suggest that seedling resistance may play a role in controlling pod infection and further investigation is ongoing.

Table 1. Mean pod infection data for 6 locations across South Australian canola growing regions

Pod infection is the percentage of pods with a blackleg lesion.

Sites	Resistance Group					
	A	B	C	D	E	G
ARTHURTON	8.0	2.0	9.8	0.0	0.0	0.0
BORDERTOWN	8.4	6.1	11.0	0.0	0.0	0.0
MT HOPE	26.3	30.2	40.6	2.7	0.0	0.8
RIVERTON	9.3	5.2	8.0	0.0	0.0	0.0
SPALDING	1.7	2.4	3.3	0.0	0.0	0.0
TURRETFIELD	2.5	4.5	5.8	0.0	0.0	0.0

Key findings on pod infection research

- Pod infection varies between sites/regions and seasonal conditions; moist conditions during flowering / pod set appear to result in pod lesions.
- Pod infection does not correlate with stem canker severity, i.e. a cankered plant may have no pod infection or a plant with no canker may have severe pod infection.
- Pod infection will result in seed infection, infected seeds may shrivel and cause yield loss. Pod lesions may also cause pod shatter causing significant yield loss. In 2013 some sites had more yield loss from pod lesions than traditional stem canker.
- Retained seed from pods with lesions will have reduced germination and seedlings may die from seedling blight.
- Spraying canola plants at the 4th leaf stage to control stem canker does not reduce pod infections.
- It is not known if later fungicide applications reduce pod infection?
- Cultivars with effective major gene resistance (seedling resistance) do not get pod lesions.

South Australia 2013 Blackleg severity

Background

- The fungal disease Blackleg can be minimised by a number of factors including sowing cultivars with high blackleg resistance, avoiding last year's stubble and applying fungicides (see 2014 Blackleg Management Guide for details - www.grdc.com.au). An additional method for minimising disease is rotating cultivars with different resistance genes.
- All canola cultivars are classified into different resistance groups. Refer to the current Blackleg Management guide for individual cultivar groups.
- Cultivars representing each of the resistance groups are sown at 32 National Variety Trial across Australia and monitored for levels of blackleg development. These data indicate which resistance groups have higher levels of disease compared to the national average at each of the regionally based NVT canola yield sites.
- It is important to note that blackleg monitoring sites are sown without any fungicide protection to seed or fertiliser and do not receive any foliar fungicide applications.

Blackleg summary - the first sign of blackleg in group E cultivars

In 2013, eight sites were monitored for blackleg severity. Each site contained each of the six blackleg resistance groups, Groups A, B, C, D, E and G. Overall blackleg severity has not increased in recent years.

In SA Group D resistance cultivars are still susceptible on the Eyre Peninsula. However the level of infection in Group D cultivars has not increased in the monitoring sites in other regions of SA.

In 2013 the Group E resistant cultivar ThumperTT was observed to have higher than average levels of blackleg infection in one site on the Eyre Peninsula. The area surrounding the site where this was established had been planted to high concentrations of Group E cultivars in 2011 and

2012. Group E is still immune to blackleg in all other sites and regions across Australia. This is the same situation as occurred with Group D cultivars in 2010 on the Eyre Peninsula. If the same pattern of increased infection occurs, the level of blackleg infection in Group E cultivars will increase in 2014 and may also become more severe in 2015.

If you are on the lower Eyre Peninsula and have grown Group E cultivars over the past two years, disease severity may increase. In 2014 do not sow Group E cultivars adjacent to Group E stubble from your 2013 crop. Monitor group E cultivars in 2014 to determine if yield loss is likely in 2015.

For individual site results consult the NVTonline website.

Summary of all Australian blackleg monitoring sites

Cultivars representing each of the resistance groups were sown adjacent to canola National Variety Trial sites across Australia and monitored for levels of blackleg. These data indicate which resistance groups have high levels of disease compared to the national average at each site.

For more detail consult the individual site summaries and recommendations on the NVTonline website.

Sclerotinia Stem Rot – the new challenge

How does the disease develop?

The fungal pathogen that causes sclerotinia stem rot is called *Sclerotinia sclerotiorum*. This fungus can infect over 300 plant species, mostly broadleaf plants, including many crop, pasture and weed species. This includes plants like canola, lupin, pulses, sunflower, lucerne, cape weed, and shepherds purse. The main features of the disease are:

- Airborne spores of the fungus are released from apothecia (a small, golf tee shaped structures, 5 – 10 mm in diameter) which germinate from sclerotia in the soil. For this to occur prolonged moist soil conditions in combination with moderate temperatures of 15°C to 25°C are considered ideal. Most sclerotia will remain viable for up to 3 – 4 years then survival slowly declines.
- Spores of the sclerotinia pathogen cannot infect canola leaves and stems directly. They require petals as a food source for spores to germinate grow and colonise the petal. When the infected petal eventually drops, it may become lodged onto a leaf, within a leaf axil or at a branch junction along the stem. If conditions are moist the fungus grows out of the petal and invades healthy plant stem tissue which will result in a stem lesion and production of further sclerotia within the stem which will be returned to the soil after harvest.
- Sclerotia also have the ability to germinate in the soil, produce mycelium and directly infect canola plants in close proximity, causing a basal infection.
- **Weather conditions during flowering play a critical role in determining the development of the disease.** Sclerotinia development requires both moisture and warm temperatures, during flowering and petal fall. Dry and/or cool conditions during this time will prevent the development of the disease. Hence, even if flower petals are infected, dry conditions or cool wet conditions during petal fall will prevent stem infection development.

Research findings in 2013

In 2013 sclerotinia was observed in all canola producing states; however it was a lot more severe in north eastern Victoria, NSW and WA. This is because in the southern growing regions rainfall is normally associated with cold fronts which result in cooler conditions not conducive to sclerotinia development.

In NSW a number of commercial canola crops were monitored for the development of sclerotinia stem rot in 2013. These crops were around Cootamundra and south of Henty, in traditionally high disease risk districts. Results from observations within these

Table 2. Summary of all Australian blackleg monitoring sites

	Group						Comments
NSW	**A**	**B**	**C**	**D**	**E**	**G**	
BECKOM	H	H	M	M	L	L	High blackleg severity in groups A, B. Moderate in C, D.
BELLATA	L	L	L	L	L	L	Low blackleg severity in all groups.
COOTAMUNDRA	H	H	L	L	L	L	High blackleg severity in groups A and B.
CUDAL	H	H	H	H	L	L	High blackleg severity in groups A, B, C and D.
GEROGERY	L	L	L	L	L	L	Low blackleg severity in all groups.
GRENFELL	H	M	L	L	L	L	High blackleg severity in group A. Moderate in group B.
LOCKHART	H	H	L	M	L	L	High blackleg severity in groups A and B. Moderate in group D.
MULLALEY	L	L	L	L	L	L	Low blackleg severity in all groups.
PARKES	H	H	M	L	L	L	High blackleg severity in groups A and B. Moderate in group C.
WAGGA WAGGA	H	H	H	H	L	L	High blackleg severity in groups A, B, C and D.
SA	**A**	**B**	**C**	**D**	**E**	**G**	
ARTHURTON	L	L	L	L	L	L	Low blackleg severity in all groups.
BORDERTOWN	L	L	L	L	L	L	Low blackleg severity in all groups.
MT HOPE	L	L	L	H	L	L	High blackleg severity in Group D.
RIVERTON	L	L	L	L	L	L	Low blackleg severity in all groups.
SPALDING	L	L	L	L	L	L	Low blackleg severity in all groups.
TURRETFIELD	H	M	L	L	L	L	High blackleg severity in group A. Moderate in Group B.
VIC	**A**	**B**	**C**	**D**	**E**	**G**	
CHARLTON	L	L	L	L	L	L	Low blackleg severity in all groups.
DIGGORA	L	L	L	L	L	L	Low blackleg severity in all groups.
HAMILTON	L	L	L	L	L	L	Low blackleg severity in all groups.
KANIVA	L	L	L	L	L	L	Low blackleg severity in all groups.
MINYIP	L	L	L	L	L	L	Low blackleg severity in all groups.
STREATHAM	L	L	L	L	L	L	Low blackleg severity in all groups.
WUNGHNU	L	H	M	L	L	L	High blackleg severity in Group B. Moderate in Group C.
YARRAWONGA	H	H	L	H	L	H	High blackleg severity in Groups A, B, D and G.
WA	**A**	**B**	**C**	**D**	**E**	**G**	
BADGINGARRA	L	L	L	L	L	L	Low blackleg severity in all groups.
CORRIGIN	L	L	L	L	L	L	Low blackleg severity in all groups.
GIBSON	L	L	L	L	L	L	Low blackleg severity in all groups.
KATANNING	L	M	L	L	L	L	Moderate blackleg severity in Groups A and B.
KENDENUP	L	M	L	L	L	L	Moderate blackleg severity in Group B.
KOJONUP	L	M	L	L	L	L	Moderate blackleg severity in Groups B.
S. STIRLING	L	L	L	L	L	L	Low blackleg severity in all groups.
WILLIAMS	L	M	L	L	L	L	Moderate blackleg severity in Group B.

Key	
	No data
L	Low blackleg severity compared to national average – continue with current management techniques.
M	Moderate blackleg severity compared to national average – Monitor crops for disease, see Blackleg management guide.
H	High blackleg severity compared to national average – high risk of yield loss, see Blackleg management guide.

crops found a very strong relationship between leaf wetness and stem rot development. While the level of stem rot development varied between the crops south of Henty and those at Cootamundra, it was found that extended periods of continual leaf wetness of at least 24 hours or longer was a critical 'trigger' point for stem rot development in both regions.

It was also found that petal infection is important in the initial establishment of stem rot. But, once canopy closure occurred and a humid microclimate is established, the infection of plant tissue under the crop canopy can provide ready opportunities for continual disease development later in the season. These tissues include lower leaves and senescent leaves that can become colonised and later adhere to stems, causing stem lesion development and yield loss. This work will continue in 2014 to collect and collate data which will be used to develop a disease prediction model.

Where did the disease occur in 2013?

In 2013 epidemics of sclerotinia in southern NSW and northern Victoria were observed in traditionally high rainfall districts. These included districts east of Cootamundra, Young and Cowra, south of Henty, around Corowa and Howlong and districts along the Murray River. Infection levels observed in some crops were as high as 30 – 60%. In other districts, crop infection levels were generally low.

Why did we observe higher levels of sclerotinia stem rot in 2013?

The weather conditions during the winter of 2013 could be considered ideal for the development of sclerotinia stem rot. Mild winter temperatures resulted in many canola crops flowering 3 – 4 weeks earlier than would be considered 'normal' for southern NSW and northern Victoria. Canola crops were observed to be flowering as early as the middle of July. These flowering crops also coincided with good rainfall throughout late July and August, which provided ideal conditions for apothecia development and release of ascospores. Frequent rainfall events throughout August provided long periods of leaf wetness and ideal conditions for infected petals to drop into wet crop canopies and allow infection to occur.

What are the indicators that sclerotinia stem rot could be a problem in 2014?

- Epidemics of sclerotinia stem rot generally occur in districts with reliable spring rainfall and long flowering periods for canola.
- Use the past frequency of sclerotinia stem rot outbreaks in the district as a guide to the likelihood of a sclerotinia outbreak. Paddocks with a recent history of sclerotinia are a good indicator of potential risk, as well as those paddocks that are adjacent.
- The commencement of flowering can determine the severity of a sclerotinia outbreak. Spore release, petal infection and stem infection have a better chance of occurring when conditions are wet for extended periods, especially for more than 24 hours. Canola crops which flower earlier in winter, when conditions are cooler and wetter, are more prone to disease development.

If I had sclerotinia in my canola crop last year, what should I do this season?

The biggest challenge in managing sclerotinia stem rot is deciding whether or not there is a risk of disease development and what will be the potential yield loss. Research in Australia and Canada has shown that the relationship between the presence of the pathogen (as infected petals) and development of sclerotinia stem rot is not very clear due to the strong reliance on moisture for infection and disease development.

Important management options include:

- **Sowing canola seed that is free of sclerotia.** This applies to growers retaining seed on farm for sowing. Consider grading seed to remove sclerotia that would otherwise be sown with the seed and infect this season's crop.
- **Separate this season's paddock away from last year's canola stubbles.** Not only does this work for other diseases such as blackleg, but also for sclerotinia.
- **Rotate canola crops.** Continual wheat/canola rotations are excellent for building up levels of viable sclerotia in the soil. A 12 month break from canola is not effective at reducing sclerotial

survival. Consider other low risk crops such as cereals, field pea or faba bean.

- **Follow recommended sowing dates and rates for your district.** Canola crops which flower early, with a bulky crop canopy are more prone to developing sclerotinia stem rot. Bulky crop canopies retain moisture and increase the likelihood of infection. Wider row spacings can also help by increasing air flow through the canopy to some degree until the canopy closes.
- **Consider the use of a foliar fungicide.** Weigh up yield potential, disease risk and costs of fungicide application when deciding to apply a foliar fungicide.
- **Monitor crops for disease development and identify the type of stem infection.** Main stem infections cause the most yield loss and indicate infection events early in the growing season. Lateral branch infections cause lower levels of yield loss and indicate infection events later in the growing season.

When is the best time to apply a foliar fungicide?

Research in Australia and Canada has shown that an application of foliar fungicide around the 20% - 30% flowering stage (20% flowering is 14 – 16 flowers on the main stem, 30% flowering is approx. 20 flowers on the main stem) can be effective in reducing the level of sclerotinia infection. The objective of the fungicide application is to prevent early infection of petals while ensuring that fungicide also penetrates into the lower crop canopy to protect potential infection sites (such as lower leaves, leaf axils and stems). Timing of fungicide application is critical.

In 2013 some commercial crops which received an application of foliar fungicide still developed stem rot later in the season. This is not unexpected as the fungicide will have a limited period of protection during a time of rapid plant growth and that the main aim of foliar fungicide applications is the prevention of main stem infections, which cause the greatest yield loss. Development of lateral branch infections later in the season is not uncommon, and will cause lower yield loss.

Consult the Sclerotinia Stem Rot in Canola Factsheet for further information. This publication is available from the GRDC website.

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Maintaining flexibility and options with pre-emergents

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Keywords

annual ryegrass, brome grass, clethodim, Sakura®, Boxer Gold®

Take home messages

- **Understanding the behaviour of pre-emergent herbicides in relation to rainfall and soil type is essential for obtaining the best results.**
- **Controlling herbicide resistant brome grass with pre-emergent herbicides is difficult and other strategies will have to be employed.**
- **A combination of pre-emergent herbicides with clethodim plus Factor® provides the best control of clethodim resistant annual ryegrass in canola.**

Understanding pre-emergent herbicides

With the release of Boxer Gold® and Sakura®, farmers now have the choice of several pre-emergent herbicides for the control of annual ryegrass in cereals. The important factors in getting pre-emergent herbicides to work effectively while minimising crop damage are: to understand the position of the weed seeds in the soil; the soil type (particularly amount of organic matter and crop residue on the surface); the solubility of the herbicide; and its ability to be bound by the soil. Managing all these factors is complex, but some rules of thumb are:

1. The more water-soluble herbicides will move more readily through the soil profile and are better suited to post sowing pre-emergent applications than the less water soluble herbicides. They are also more likely to produce crop damage after heavy rain.
2. Soils with low organic matter are particularly prone to crop damage from pre-emergent herbicides (especially sandy soils) and rates should be reduced where necessary to lower the risk of crop damage.
3. If the soil is dry on the surface, but moist underneath there may be sufficient moisture to germinate the weed seeds, but not enough to activate the herbicide. Poor weed control is likely under these circumstances. The more water soluble herbicides will work more effectively under these conditions.
4. Pre-emergent herbicides need to be at a sufficient concentration, and at or below the weed seed (except for Avadex®Xtra which needs to be above the weed seed) to provide effective control. Keeping weed seeds on the soil surface will improve control by pre-emergent herbicides.

5. Many pre-emergent herbicides can cause crop damage. Separation of the product from the crop seed is essential. In particular care needs to be taken with disc seeding equipment in choice of product and maintaining an adequate seeding depth.
6. High crop residue loads on the soil surface are not conducive to pre-emergent herbicides working well as they keep the herbicide from contact with the seed. More water soluble herbicides cope better with crop residue, but the best solution is to manage crop residue so that at least 50% of the soil surface is exposed at the time of application.

Table 1 provides a comparison of water solubility and strength of binding to organic matter of several common pre-emergent herbicides. A key facet to getting pre-emergent herbicides to work is to understand their solubility in water. Trifluralin and pendimethalin (Stomp®) are the least water soluble herbicides, whereas Boxer Gold® (containing prosulfocarb and S-metolachlor) is one of the most soluble. This means less moisture is required for activation of Boxer Gold® than for Sakura®. Our rule of thumb is that 5 to 10 mm of rainfall in the 10 days after sowing is fine for Boxer Gold®, but 10-15 mm is required for Sakurav.

Greater water solubility also means more mobility in the soil and higher risk of crop damage with heavy rain after sowing. Herbicide washing into the crop row can damage the emerging crop. This is particularly a problem in light soils with low organic matter. Movement of herbicides in the soil profile is strongly influenced by their binding to soil organic matter. Trifluralin and pendimethalin are strongly bound to organic matter in the soil. This means they will not move far from where they are applied. In contrast, Sakura® and S-metolachlor (in Dual Gold® and Boxer Gold®) are bound much less tightly and are prone to movement in soils with low organic matter. In such soils, consideration should be given to reducing rates to reduce the risk of crop damage.

Table 1. Water solubility and binding to soil organic matter (K_{oc}) for some common pre-emergent herbicides

Herbicide	Trade Name	Water solubility (mg L^{-1})*		K_{oc} (mL g^{-1})**	
Trifluralin	TriflurX®	0.22	Very low	15,800	Very high
Pendimethalin	Stomp®	0.33	Very low	17,800	Very high
Pyroxasulfone	Sakura®	3.9	Low	223	Medium
Triallate	Avadex® Xtra	4.1	Low	3000	High
Prosulfocarb	Boxer Gold®***	13	Low	2000	High
Atrazine		35	Medium	100	Medium
Diuron		36	Medium	813	High
S-metolachlor	Dual Gold®	480	High	200	Medium
Triasulfuron	Logran®	815	High	60	Low
Chlorsulfuron	Glean®	12,500	Very High	40	Low

**at 20 C and neutral pH; **in typical neutral soils; ***also contains S-metolachlor*

Most weed seeds are on or close to the soil surface after crop harvest. As most pre-emergent herbicides, except triallate (Avadex® Xtra), are absorbed by the roots or the mesocotyl (the part of the shoot emerging from the seed) the ideal situation is to have the herbicides concentrated immediately below the weed seed. No-till systems, where seed are maintained on the soil surface until the pre-emergent herbicide is applied are ideal for efficacy of pre-emergent herbicides.

Due to its different action in the soil profile, addition of Avadex® Xtra to other grass pre-emergent herbicides generally results in increased levels of control of annual ryegrass. Essentially, the mixture allows weeds germinating both at the top of the soil profile and below the soil surface to be controlled.

Pre-emergent herbicides for brome grass management

The increasing incidence of resistance in brome grass to post-emergent Group A and Group B herbicides in Victoria and South Australia is making brome management more difficult. Brome grass provides several challenges to management in the absence of post-emergent herbicides.

Firstly, brome grass tends to have extended dormancy providing staggered germination through the season. This means that all pre-emergent herbicides struggle to control brome, but those with low soil persistence, such as Boxer Gold®, are particularly poor. Also, if any brome grass has germinated prior to application of the herbicides, it will be less well controlled.

Secondly, brome grass tends to occur in low rainfall regions. These regions have less moisture to activate pre-emergent herbicides. In addition, crops tend to be less competitive and competition from crops is important in getting the best from pre-emergent herbicides.

We have been conducting a series of trials to determine the ability of various pre-emergent herbicides to control brome. Trials have been conducted at various sites in SA and Victoria and on both species of brome. Generally pre-emergent herbicides are much less effective on brome grass than they are on annual ryegrass.

Figure 1 shows a compilation of data from five trials as reduction in the number of brome panicles at the end of the season. The horizontal line in the centre of each column is the mean of the five trials. The bar is the standard error. Common product mixtures, such as trifluralin plus metribuzin only provided about 50% reduction in brome panicles. Sakura® on its own provided similar or less control. Sakura® plus high rates of Avadex® Xtra generally provided high levels of control, but this treatment was poor in one trial.

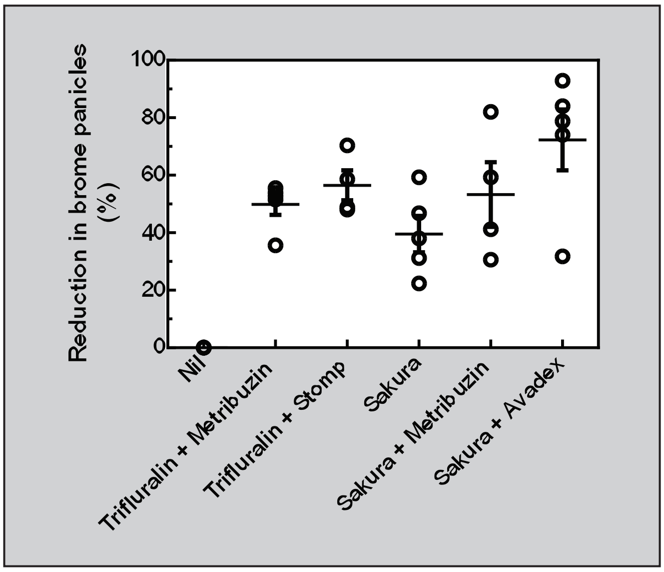

Figure 1. Average reduction in brome grass panicles with pre-emergent herbicide mixtures across 5 trials in southern Australia.

Control of brome grass in the absence of effective post-emergent herbicides will be difficult. Taking opportunities to reduce seed set of brome in non-cereal phases in the rotation will be important for the long-term management of this weed.

Control of clethodim resistant ryegrass

The increasing incidence of clethodim resistance in annual ryegrass is making weed management in break crops more difficult. We have conducted experiments to identify management practices that might be effective at managing clethodim resistant ryegrass focussing on novel pre-emergent herbicides. In 2013 we conducted a trial examining alternative strategies in both open-pollinated TT and

Table 2. Effect of alternative herbicide strategies for control of clethodim resistant annual ryegrass in TT canola on ryegrass seed heads and canola yield

Treatment	Ryegrass seed heads (spikes m^{-2})	Yield (T ha^{-1})
1.5 kg ha^{-1} Atrazine IBS fb 500 L ha^{-1} Clethodim POST	51	2.15
1.5 kg ha^{-1} Atrazine IBS fb 1.0 kg ha^{-1} Atrazine + 500 ml ha^{-1} Clethodim POST	33	2.15
1.5 kg ha^{-1} Atrazine IBS fb 500 ml ha^{-1} Clethodim + 80 g ha^{-1} Factor POST	60	2.20
Exp 1 IBS	326	1.62
Exp 2 IBS	231	1.68
Exp 2 IBS fb 500 L ha^{-1} Clethodim POST	79	2.02
Exp 2 IBS fb Exp 2 POST	178	1.77
Exp 3 IBS	477	1.30
Exp 3 + 2.0 L ha^{-1} Avadex Xtra IBS	308	1.65
Exp 3 IBS + 2.5 kg ha^{-1} Atrazine POST	103	1.99
1.5 kg ha^{-1} Atrazine IBS + Exp 4 POST	67	2.16
LSD	108.7	0.22

Table 3. Effect of alternative herbicide strategies for control of clethodim resistant annual ryegrass in Clearfield canola on ryegrass seed heads and canola yield

Treatment	Ryegrass seed heads (spikes m^{-2})	Yield (T ha^{-1})
2.0 L ha^{-1} Trifluralin + 2.0 L ha^{-1} Avadex X IBS fb 750 ml ha^{-1} Intervix + 500 ml ha^{-1} Clethodim POST	43.8	1.69
2.0 L ha^{-1} Trifluralin + 2.0 L ha^{-1} Avadex X IBS fb 750 ml ha^{-1} Intervix + 500 ml ha^{-1} Clethodim + 80 g ha^{-1} Factor POST	31.3	1.68
Exp 1 IBS	141.7	1.55
Exp 2 IBS	9.7	1.60
Exp 2 IBS fb 500 L ha-1 Clethodim POST	14.6	1.62
Exp 2 IBS fb Exp 2 POST	61.5	1.63
Exp 3 IBS	156.3	1.60
Exp 3 + 2.0 L ha^{-1} Avadex Xtra IBS	139.6	1.49
Exp 3 IBS + Exp 2 POST	100.0	1.65
2.0 L ha^{-1} Trifluralin IBS + Exp 4 POST	13.0	1.46
LSD	43.0	0.21

hybrid Clearfield™ canola. The ryegrass population had resistance to both clethodim and Intervix®, so these products were not very effective (Tables 2 and 3).

The growing conditions were above average rainfall during winter followed by much below average rainfall in spring. The Clearfield™ hybrid grew very rapidly in autumn and winter leading to lower ryegrass numbers, but the dry spring had a negative impact on yield. The wet winter conditions favoured the activity of atrazine in the TT canola, but worked against the activity of some of the novel pre-emergent herbicides. Failure to control ryegrass in TT canola with pre-emergent herbicides alone resulted in significant yield reductions of up to 40% (Table 2). There was less impact of weeds on yield in the more competitive Clearfield™ hybrid (Table 3). In addition, the competition from the Clearfield™ hybrid greatly improved the performance of some of the pre-emergent herbicides, particularly within experiment 2.

Even with clethodim resistance present in ryegrass, the best currently registered treatments still contained clethodim and Factor®. None of the alternative treatments were consistently more effective than the clethodim treatments.

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Notes

Slug management practices – what is working?

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GRDC project code: SFS 0023

Keywords

slugs, canola, bait, rolling, stubble, species identification

Take home messages

- **Managing slug populations is unlikely to be successful unless both cultural and chemical control strategies are used.**
- **Research has found burning, light cultivation and rolling improves slug control.**
- **Control measures must be carried out before slug damage is observed.**
- **Paddocks with a previous history of slug damage are always a good place to start monitoring in a susceptible crop like canola.**
- **Slug bait should be applied at a rate to provide sufficient bait points per m2 relative to slug populations in the paddock.**
- **Check the accuracy of your bait spreader to make sure there is an even distribution of bait across the spreading width. This width may not be the same as the width you spread urea.**
- **Identify slug species present in a paddock for the most effective control. Different species demonstrate different behaviours.**

Slugs are a major pest that regularly damage emerging and seedling canola, fodder rape, pasture legumes and to a lesser extent cereal crops and pulses. The consequences and costs of slugs and damage or the potential to cause damage are:

- Re-sowing (additional seed and sowing costs and not sowing at the optimum time and hence potential yield is reduced).
- Costs of baits and baiting (multiple applications).
- Burning of stubble.
- Cultivation.
- Reduced area sown to canola.

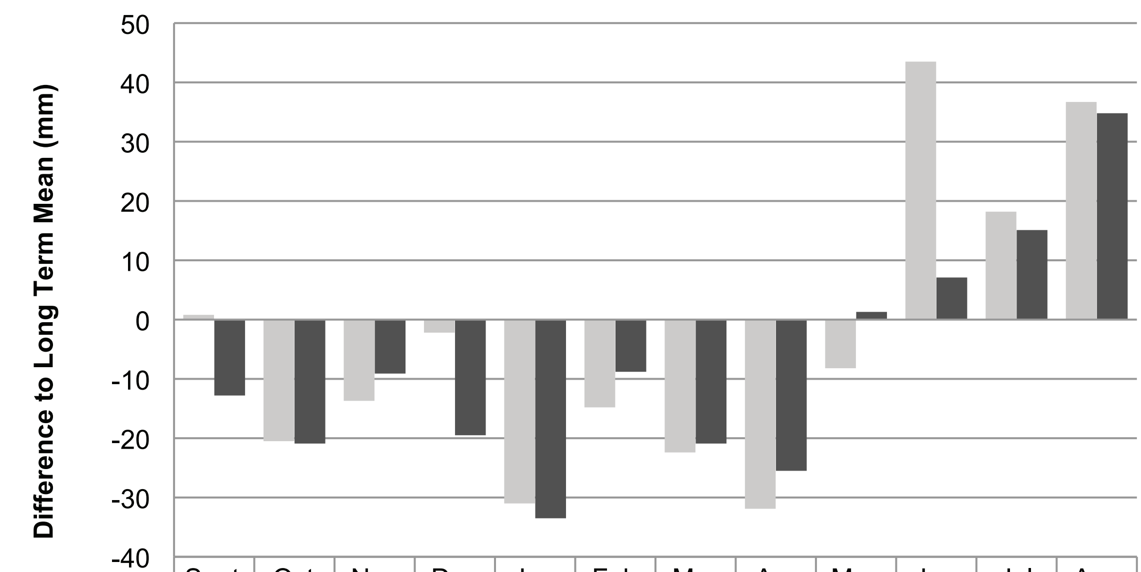
Slugs have been an intermittent pest of crops in the HRZ. However, the frequency and level of damage caused by this pest has gradually increased over time. Slugs are now constant and major pests that frequently cause significant damage to crops at emergence and during the establishment phase. This may be attributed to a number of factors including the increase in adoption of stubble retention and reduced tillage and increased area of susceptible crops such as canola. The area of damage caused by slugs has increased irrespective of favourable climatic conditions, including the drought of 2006.

Slugs have caused significant damage to some canola during the germinating and early establishment phase of crops in 2013, especially in areas where damage had been seen previously. The extent of damage was unexpected given the very dry conditions of summer and autumn. The adoption of stubble retention has favoured this pest through increased soil moisture holding capacity and the stubble providing a refuge for the slugs to survive.

Knowledge and skills to monitor slug populations and implement an effective slug control strategy are critical to reduce the impact of slugs. Currently growers, agronomists and advisers do not always use effective strategies that will consistently control slugs below thresholds for growing canola. The most common strategy often starts with applying slug bait once damage is seen in the establishing crop. Unfortunately this approach is reactionary and doesn't lead to the most effective level of control. Following the very high levels of damage seen in 2011, many growers are now looking to include additional cultural control techniques; including burning of stubble, cultivation and rolling.

During the spring of 2012 the GRDC HRZ Regional Cropping Solutions group put forward the research topic of "managing slugs in the HRZ" as a major priority for growers and advisers. As a result, a fast track project was initiated to demonstrate and evaluate a range of management strategies that could effectively reduce damage to emerging canola during establishment caused by slug species in the High Rainfall Zone (HRZ).

Twelve farms were surveyed across the western districts of southern Victoria that were considered suitable as potential trial sites based on grower and adviser recommendations. All had sufficient slugs in the spring sampling to be potential trial sites. The key factor for the project would be, what would happen to the slugs over the summer, and what mortality rates will occur? The aim was to have at least three final sites which fitted the project criteria, with the target species being the Grey Field Slug (*Deroceras reticulatum*), as this is the dominant species in the western districts and at least one site where Black Keel slug (*Milax gagates*) was the focus species. The rationale for this was that there is a shift in species prevalence in response to seasonal conditions, and therefore, it is important to understand management control options for both kinds of slug species. The final sites were at Inverleigh (east), Skipton (central) and Hamilton (west).



	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Winchelsea	0.8	-20.5	-13.7	-2.2	-31	-14.8	-22.4	-31.9	-8.2	43.5	18.2	36.7
Hamilton	-12.8	-20.9	-9.1	-19.5	-33.5	-8.8	-20.9	-25.5	1.3	7.1	15.1	34.8

Figure 1. Difference in actual rainfall at 2 sites compared to the Long term mean from September 2012 to August 2013.

The very dry conditions experienced in southern Victoria over the summer months affected the final methodology used in the project and some cultural management techniques were not employed either by grower request or by what was actually achievable at each site. The data below shows the variation from the long term mean at two of the sites, from September 2012 to August 2013. Winchelsea BOM rainfall was used for the Inverleigh site.

The final trial plan was:

1. Stubble – all stubble from the previous crop was burnt.
2. Cultivation – none undertaken as too dry and growers didn't want to use this intervention.
3. Rolling – rolling versus control. This was carried out using rubber tyre rollers.
4. Grazing – grazing versus ungrazed. Only one site grazed the stubble pre burning.
5. Baiting:
    - Applied immediately after sowing versus "grower strategy" baiting versus double bait.
    - Applied at full label rate versus "grower rate".

Results

Inverleigh Site

The canola variety, Crusher⏀, was sown on the 21st May into burnt barley stubble. Sowing rate of 4.2kg/ha on a 300mm row spacing. The slug species identified in this trial were the grey field slug (*Deroceras reticulatum*), the black keeled slug (*Milax gagates*) (Black Keeled Slug) and the striped field slug (*Lehmannia nyctelia*).

Skipton Site

The canola variety, Thunder, was sown on the 17th May into burnt wheat stubble which was grazed. Sowing rate of 4.0kg/ha on a 220mm row spacing. The slug species identified in this trial was the grey field slug (*Deroceras reticulatum*).

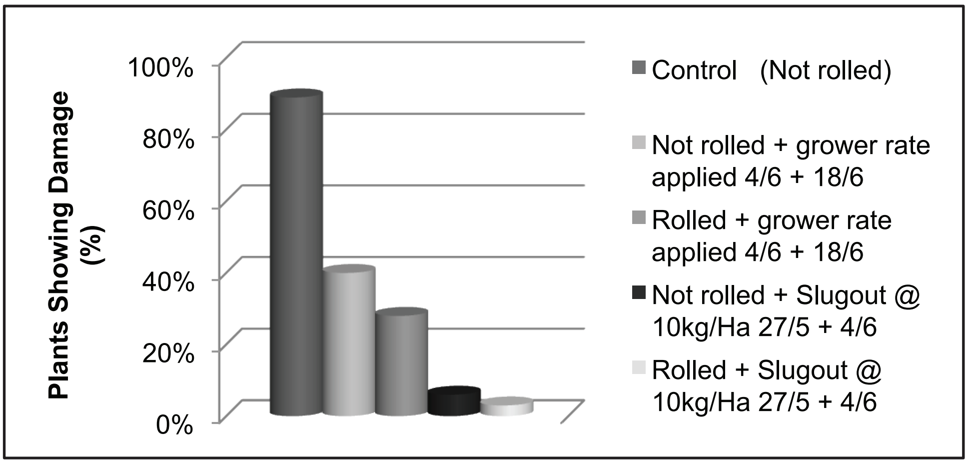


Figure 2. Effect of each treatment on the plants displaying any slug damage (Inverleigh trial).

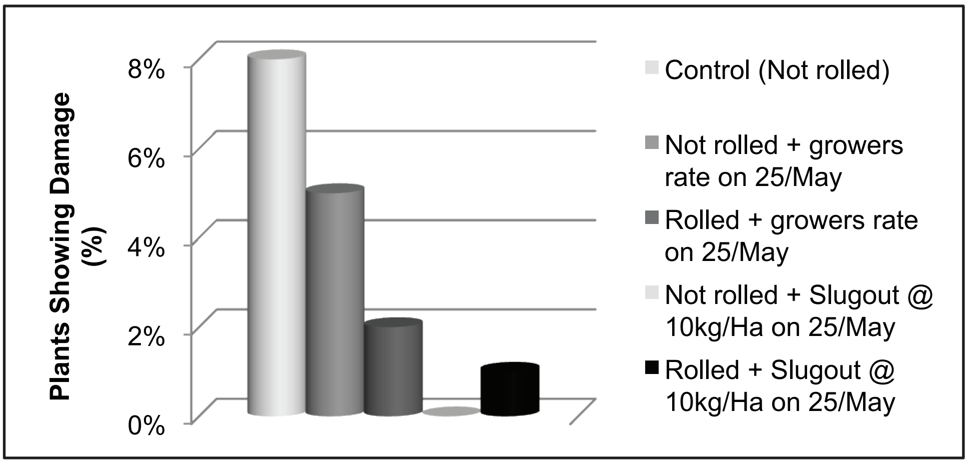


Figure 3. Effect of each treatment on the plants displaying any slug damage (Skipton trial).

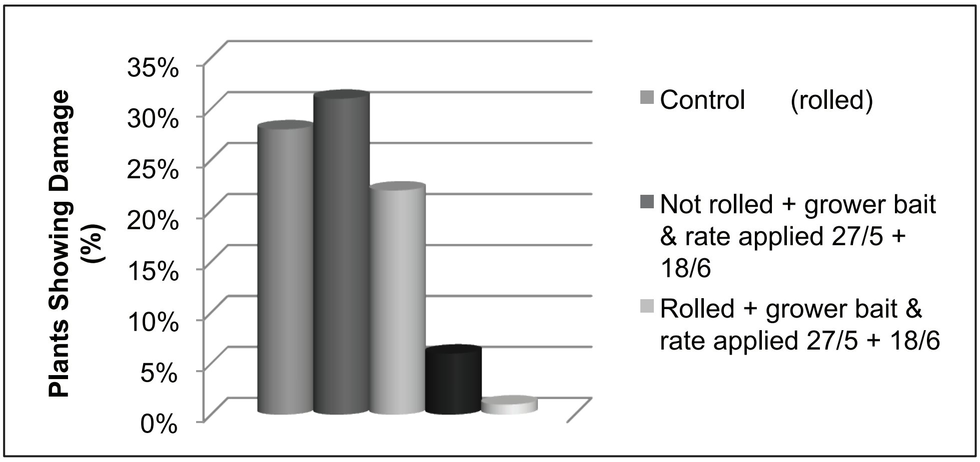


Figure 4. Effect of each treatment on the plants displaying any slug damage (Hamilton trial).

Hamilton Site

The canola variety, Thunder, was sown on the 14th May into burnt wheat stubble. Sowing rate of 3.5/ha broadcast and prickle chained. The slug species identified in this trial were the grey field slug (*Deroceras reticulatum*) and the black keeled slug (*Milax gagates*).

What did we learn?

Timing of the bait

All the managed bait applications showed the lowest level of slug damage across all sites. This application was also applied post sowing but pre emergence of the crop and this gave a substantially improved level of control especially at Inverleigh and Hamilton where the first grower application was applied 8 days later.

Influence of Rolling PSPE

All sites showed a positive result from rolling immediately after sowing compared to not rolling. This was especially noticeable at Inverleigh and at Hamilton where there were higher slug numbers and damage. This was nicely demonstrated at Hamilton where the control treatment was rolled and resulted in less crop damage compared to applying bait but not rolling. This is a cheap, non-chemical, cultural control technique which restricts slug movement in the seed bed and also helps to consolidate soil around the newly sown seed, and therefore, improves establishment.

Rate of Slug Bait

It is difficult to draw any conclusions from the differences in rates of product used as there were also differences in timing of application, which in itself almost certainly had a major influence on control. However, growers are often driven by what a bait will cost them per hectare and its perceived ability to tolerate wet weather and remain active (i.e. not disintegrate). In light of this we looked at five commonly used baits and measured bait points/m^2 at full label rate compared to commonly used “grower rates” (Figure 5).

For many slug bait products, growers tend to have their own rates of application. This is often driven by cost/ha and can also be influenced by what rate their bait spreader is set up at! A common application rate is 4 to 5 kg/ha which equates to $30 - $35/ha. However, this is very often applied without any understanding of bait points per square metre, which needs to be at about 25/m^2 for a paddock population of 20 slugs/m^2, assuming 80% encounter (Nash 2013). A slug population of one per square metre is significant, and is considered the damage threshold for canola. An infestation of eight slugs per square metre is considered severe (Sabeeney 2013).

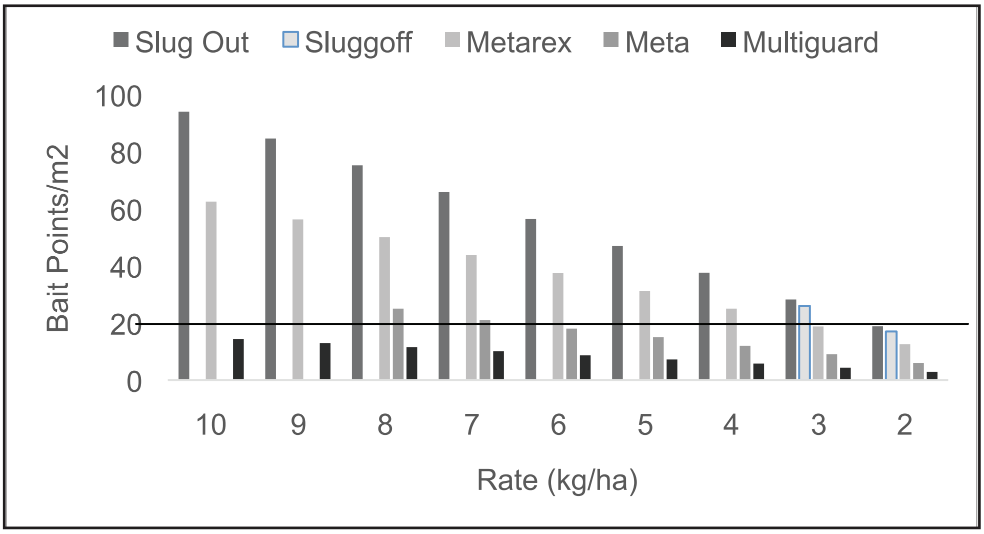


Figure 5. Bait points per square meter at various application rates (kg/ha).

Spreading Slug Bait

Recent research carried out by Ashley Wakefield and Greg Baker in SA on the distribution of slug and snail bait from standard farm spreaders adds further potential inaccuracy to applying bait:

- Many growers assume bait spreading requires the same machinery setup as urea spreading.
- Many growers are not spreading the product as widely as they think when using spreaders set-up for urea rather than for bait.
- Ute spreaders, set up for urea to spread to 15 meters were spreading bait to 7 meters only.
- Fertiliser spreaders, thought to be spreading bait to 35 meters were spreading bait to 20 meters only.
- During the spreading process, some of the bait was breaking up into smaller pieces. At this stage this is not seen as either a disadvantage or an advantage.

Species Identification

At both the Hamilton and Inverleigh trials, damage levels were higher than at the Skipton trial. One explanation for this may well have been the presence of two species of slugs which can live at different depths in the soil.

The Grey field slug or reticulated slug (*Deroceras reticulatum*) is mainly surface active and can have up to three generations a year. It will generally breed in autumn and spring however, if conditions are favourable this species will breed any time, and therefore, a pair can produce up to 1000 eggs a year. The second species identified at these two sites was the Black keeled slug (*Milax gagates*). This species can burrow up to 20 centimetres underground to escape the heat. A breeding pair can lay up to 200 eggs a year.

The importance of identification of the species relates to the emergence of each species as the autumn break developed. At the very early emergence stage of canola, only grey field slugs were causing plant damage but as the wet front penetrated the soil profile with increased rain, the black keeled slugs became active. This meant that only applying the initial bait treatment PSPE wasn't going to be sufficient to control the later emerging species.

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Notes

Maximising the nitrogen (N) benefits of rhizobial inoculation

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Take home messages

- **Inoculation of legumes with rhizobia can deliver substantial N inputs to southern farming systems even when the impact on legume yield is small.**
- **Targeted, strategic use of inoculants, using a risk/benefit approach is the best and most cost effective way to maximise N inputs from legumes.**
- **To maximise the chances of getting a positive response to inoculation, follow the guidelines that are set out in recent GRDC publications.**
- **Care needs to be taken in situations where the survival of rhizobia is compromised, such as dry sowing, acid soils, mixing with fertilisers and pesticides; follow the guidelines.**

Introduction

Inoculation of legumes with rhizobia is a standard practice. However, we can optimise legume nodulation and improve nitrogen inputs by following a few basic rules of thumb and fine-tuning inoculation practices.

A recent national survey of legume growers has yielded useful information about current farmer knowledge and practice in relation to rhizobial inoculation. The results of the survey are being used to guide and refine key messages going out to growers.

Inoculation can greatly increase the amount of biologically fixed N from legumes where they are sown for the first time or where soils are not conducive to rhizobial survival. For example, inoculation of faba bean in south western Victoria boosted fixed N from 32 to 196 kg N/ha, as well as increasing dry matter production and increasing yield by 1 tonne per ha compared with an uninoculated crop (Denton et al. 2013). However, it is also common for growers to get fixed N benefits from inoculation even when the inoculation only leads to a small yield increase.

You have probably heard the phrases ‘if in doubt, inoculate’ and ‘inoculation is cheap insurance’ as well as the message to ‘inoculate every year’. These messages are sometimes appropriate, but may lead to unnecessary inoculation in some instances, or alternatively cause growers to become cynical about the need for inoculation which can result in the sub-optimal use of inoculant. It is possible to adopt a more targeted and strategic approach to inoculation and N management by using some basic rules of thumb as guides about when and where it is best to inoculate.

A risk/benefit framework can be used with respect to the likelihood of obtaining a positive response to inoculation to assist in decision-making, through consideration of soil type, legume species and inoculation history.

After making the decision to inoculate, it is worth maximising the chances of success, as inoculation failure is generally difficult and expensive to remedy. Again, following some general guidelines will be helpful to ensure successful legume nodulation, noting that there is a range of inoculant products available, with different application methods.

Changing practices on farm, such as the trend towards early (dry) sowing in some regions, is taking us into new territory with respect to recommendations about rhizobial inoculation. Another important and common practical issue is the degree of compatibility between rhizobial inoculant and fertilisers and seed-applied pesticides and additives. Although it would be useful to know the compatibility of each rhizobial strain with all of the common chemical formulations, this information is currently not available.

The recent national survey of legumes growers has highlighted the need for common-sense, practical guidelines so that inoculation can be practised successfully in the context of a grower's preferred operations at sowing. Several recent GRDC publications give useful information about optimising inoculation and nitrogen inputs from N fixation. These publications are available online or from the GRDC, and are listed at the end of the paper.

Nitrogen fixation benefits

Legumes (crop and pasture combined) are estimated to fix almost 3 million tonnes of nitrogen each year in Australia, which is worth around $4 billion. This amount of fixed N makes a substantial (around 50 per cent) contribution to the estimated 6 million tonnes of nitrogen that are required annually for grain and animal production on Australian farms.

The contributions made by legumes vary considerably with the species (Table 1) and with the situation (soil type, seasonal rainfall and crop management). Crop legumes fix about 110 kg of N per hectare annually, on average (Table 1). However the range is large, varying in individual paddocks from close to zero to more than 400 kg N/ha.

Nitrogen fixation generally increases with increased crop biomass, therefore good agronomic management leading to good legume growth will favour higher N inputs from fixed N. There are also significant contributions of fixed N from legume roots (Table 1). In the southern Australian environment, legume growth is strongly influenced by the amount of water that the crop or pasture can

Table 1. Estimates of the amounts of N fixed annually by crop legumes in Australia

Legume	% of crop N requirement fixed	Shoot dry matter (t/ha)	Shoot N (kg/ha)	Root N (kg/ha	Total crop N (kg/ha)	Total N fixed[1] (kg/ha)
Lupin	75	5.0	125	51	176	130
Pea	66	4.8	115	47	162	105
Faba bean	65	4.3	122	50	172	110
Lentil	60	2.6	68	28	96	58
Soybean	48	10.8	250	123	373	180
Chickpea	41	5.0	85	85	170	70

[1]*Total N fixed = Percent N fixed x Total crop N; data sourced primarily from Unkovich et al. (2010).*

access from the combination of stored soil moisture and growing season rainfall. Management practices that optimise water use efficiency, and also keep soil nitrate levels low, will favour legume growth and N fixation. The fixed N is used by the legume itself for growth, but any root and shoot residues remaining after grain harvest or pasture grazing (for pastures legumes) will contribute to soil nitrate which can provide N to subsequent crops.

Nitrogen fixation is greater when soil nitrate is below 50 kg/ha and virtually ceases at nitrate levels above 200 kg/ha (Figure 1). Nitrogen fixation by chickpea (Figure 1) and field pea is more sensitive to high soil nitrate than for faba bean.

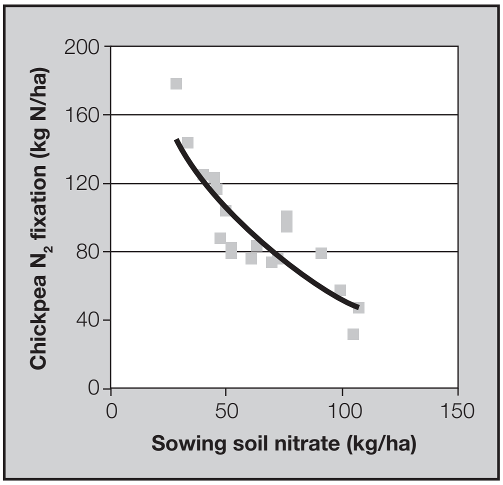

Figure 1. Impact of soil nitrate on chickpea nitrogen fixation in northern NSW. Source: unpublished data of WL Felton, H Marcellos, DF Herridge, GD Schwenke and MB Peoples.

In addition to providing an N benefit, legumes can provide a disease break benefit to increase the productivity of following cereal and oilseed crops by reducing the inoculum levels of key soil-borne pests such as nematodes and also fungal diseases. Cereals grown after legumes generally out-yield cereals grown after non-leguminous crops, partly due to the N benefit and partly due to pest and disease control by the legume break crop.

When, where and how to inoculate?

There is a low likelihood of response to inoculating grain legume crops or pastures where there has been a recent history of inoculation with the appropriate rhizobia (i.e. the correct inoculant group); the soil pH is above 6 (in CaCl2); and recent nodulation, grain yields and pasture production have been good. In these situations, inoculation every four years or so will be adequate because soil rhizobial populations will generally be maintained at above 1,000 per gram, which is considered adequate for good nodulation. After four years there is increased likelihood of a response to inoculation because the rhizobia that persist in the soil can lose some of their capacity to fix nitrogen, so a top-up with the potent inoculation strain may be beneficial. If the legume species (or another that uses the same rhizobia) has not been grown in the last four years, or soil conditions are hostile, then the probability of a response to inoculation is greater.

Such is the case where acid sensitive legumes (e.g. peas and beans) are sown into acid soils (pH 5.5 or less in $CaCl_2$). In these situations it will be prudent to inoculate every time a crop is sown because rhizobial populations tend to diminish quickly under these soil conditions (refer to Table 2). The exception to this acid soil rule is lupin, because both lupin and its rhizobial strain are well-adapted to acid soils.

Where a crop such as chickpea, which has a very specific rhizobia requirement, is grown for the first time, inoculation is essential as there will be no background of suitable rhizobia present. A double rate of inoculant is often used in these situations, to enhance the likelihood of good nodulation.

In the recent GRDC publications about rhizobial inoculation, ‘good nodulation’ and ‘well-nodulated crops’ are frequently referred to, and guidelines

Table 2. Sensitivity of key rhizobia to pH (■ is sensitive, ■ is optimal)

Host legume	Rhizobia	pH 4	pH 5	pH 6	pH 7	pH 8
Lupin, serradella cowpea, mungbean	*Bradyrhizobium* spp.					
Soybean	*Bradyrhizobium japonicum*					
Clovers	*Rhizobium leguminosarum* bv. *trifolii*					
Pea, faba bean, lentil, vetch	*Rhizobium leguminosarum* bv. *viciae*					
Chickpea	*Mesorhizobium ciceri*					
Medics	*Sinorhizobium* spp.					

are given about adequate numbers of nodules per plant. How do we go about checking this? We strongly encourage growers and/or consultants to look below the soil surface, dig up several plants about 2-3 months after sowing, wash out the root systems gently and look at the level of nodulation on the roots. This is important, as it will help a grower to decide on the need for inoculation in future years. A guide to assessing nodulation in pulse crops is provided at www.agwine.adelaide.edu.au/research/farming/legumes-nitrogen/legume-inoculation/.

A visual check of root systems is worthwhile to establish if a reasonable number of nodules is present and well distributed across the root system or whether there has been a nodulation delay or failure. Carefully breaking open nodules to determine if there is a pink or reddish colour in the nodules will show that the nodules are active. Neither of these visual assessments, however, will give an indication of the actual level of N fixation being achieved; sophisticated scientific techniques are required to measure this.

Common inoculation issues faced by growers

Can I sow inoculated seed into dry soil?

Growers in some regions want to sow legumes early into dry soil. Sowing inoculated seed into dry soil is not recommended where a legume crop is sown for the first time. On the other hand, where a legume has been used frequently and the soil is not particularly hostile to rhizobia, the risk of nodulation failure resulting from dry sowing is much reduced. Rhizobial formulations which are applied in furrow, such as granules or peat suspended in liquid, are placed deeper in the soil and will have a better chance of survival as the soil conditions will be less extreme at greater depth. There is also some evidence from field trials that placing the inoculum deeper in the soil is beneficial in a dry sowing, but it should be noted that there has not been a great deal of definitive research on this topic to date.

Can I mix inoculated seed with fertiliser, including trace elements?

Some growers claim success in mixing rhizobial inoculant with fertiliser and/or trace elements.

Rhizobium biologists recommend against mixing inoculant with fertilisers (particularly superphosphate and others that are very acidic) or other, novel plant nutrition treatments. However we recognise that farming operations need to be pragmatic for practical and economic reasons. Small scale testing is highly recommended where mixing inoculum with fertilisers and micro-nutrients is contemplated. Tanks should be cleaned well before they are used for rhizobial inoculum. Placement of the fertiliser or trace elements away from the rhizobial inoculum (e.g. in furrow below the seed) is highly recommended. It is worth noting that the detrimental effects of mixing inoculants and fertilisers etc. are often overlooked because legumes are often sown in paddocks not responsive to inoculation. It is only when a nodulation problem suddenly appears in a paddock that is responsive to inoculation, that the harmful effect of mixing rhizobia with other products is considered.

If molybdenum is required as a seed treatment (Mo is sometimes needed for optimum nodulation, especially in acid soils), then molybdenum trioxide or ammonium molybdate should be used, NOT sodium molybdate (toxic to rhizobia!).

Can I mix rhizobial inoculant with seed pickles and pesticides?

Some combinations of rhizobia with some pickles and pesticides appear to perform satisfactorily, whereas others are very effective at destroying rhizobia. The booklet *Inoculating Legumes: a practical guide* (see further readings) contains a table on page 40 that lists the compatibility of different rhizobia groups with seed-applied fungicides, and also discusses specific compatibility issues between rhizobia and certain insecticides and herbicides. Pickled seed can be coated with rhizobia (except soybean and peanut), but the time interval between inoculation and sowing should be kept to a minimum, usually less than six hours. The use of granular inoculants or liquid inoculantion into furrows can reduce this impact by separating the pickled seed from the inoculant.

The following mixtures are NOT compatible with peat, liquid and freeze-dried inoculants:

- chemicals containing high levels of zinc, copper or mercury;
- fertilisers and seed dressings containing sodium molybdate, zinc and manganese;
- fungicides such as Sumisclex® or Rovral®
- herbicides such as MCPA, 2,4-D and Dinoseb; and
- insecticides containing endosulfan, dimethoate, omethoate, or carbofuran.

National survey of legume growers

The survey, conducted in 2013, comprised 18 questions that explored grower knowledge and practice in relation to rhizobial inoculation. It was completed by 405 growers, representing a farmed area of just over 1 million hectares, across all GRDC regions.

Results are still being analysed in detail, but initial indications are available. Growers generally had a good level of knowledge about rhizobia and their use, though ten per cent did not know that rhizobia fall into different groups that are specific to certain crop and pasture legumes. Virtually all growers know that rhizobia are living organisms, but 22 per cent stated that it was fine to mix rhizobia with fertiliser and eight per cent thought it was acceptable to mix rhizobia with pesticides. As discussed above, combinations and mixtures can work in some circumstances, but care must be taken to avoid incompatibility and the risk of inoculation failure.

Ninety percent of survey respondents reported that they used inoculants. Of the ten per cent that did not inoculate, over half specified that inconvenience was a reason and also that the benefit was not clear.

Peat formulation was by far the most common method of application (used by 82 per cent of respondents). Other formulations were also important however, including granules (19 per cent) and freeze-dried formulations (14 per cent). A substantial proportion of growers used more than one type of formulation.

Further reading

Inoculating Legumes: a practical guide (GRDC 2012) Free, online at www.grdc.com.au/GRDC-Booklet-InoculatingLegumes

Inoculating Legumes: The Back Pocket Guide (GRDC 2013) Free, online at www.grdc.com.au/Resources/Publications/2013/09/Inoculating-legumes-back-pocket-guide

Fact Sheet: Rhizobial inoculants (GRDC 2013) Free, online at www.grdc.com.au/~/media/B943F697AF9A406ABBA20E136FDB7DC4.pdf

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Is social media working for you?

Prudence Cook,
Department of Environment and Primary Industries, Victoria

Keywords

social media, Twitter, Google +, LinkedIn, social media manager, access to information, networking, reputation management

Take home messages

- **Social media will become increasingly important to the workforce in the future.**
- **Social media channels can be used as sources of timely, relevant information.**
- **Using social media allows you to build networks outside of geographic boundaries.**
- **Having a professional online presence is crucial for reputation and brand management.**

Introduction

Some digital technologies; namely smart devices and apps, have been adopted rapidly in a short time frame with approximately 70 per cent of advisers now owning a tablet, despite the iPad only being commercially available since 2010. The benefit of these devices and their supporting applications are clearly apparent; you purchase a device and download the apps according to the functions you want it to perform. However, the benefits of social media, particularly for professionals who are not directly involved in marketing and communications, are much less obvious. Despite this, several benefits do exist, and having a grasp on these new media channels will become increasingly important as the Australian workforce incorporates more and more technological components.

Adopting social media, particularly from a professional standpoint, brings with it the need for many to develop new skills. Given that up-skilling can be a time consuming and costly exercise, you'd want to be certain that the skill will be needed in the long term. With that in mind, it's worth considering what core capabilities will be required in the workforce in the future. A report conducted by the Institute for the Future, looked at key drivers that will reshape the landscape of work and the key skills that will be needed in the next ten years. Ten key skills were identified:

- New media literacy: The ability to develop content online to communicate persuasively.
- Computational thinking: The ability to translate vast amounts of data.
- Transdisciplinary working: The ability to understand concepts across multiple disciplines.
- Cognitive load management: The ability to filter information depending on importance.
- Virtual collaboration: Work productively as a member of a virtual team.
- Sense making: The ability to determine greater significance from given information.

- Social intelligence: The ability to network and draw information from peers.
- Novel and adaptive thinking: The ability to find innovative solutions different to the norm.
- Cross cultural competency: The ability to work with an increasingly diverse workforce.
- Design mindset: The ability to develop tasks and processes for desired outcomes.

An understanding of social media can assist you in acquiring the above skill set through quickly accessing reliable information from a diverse range of sources and adapting that information into a local context. Staying abreast of happenings online will benefit continual professional development and ensure that your skill set remains aligned with an increasingly digital workforce.

In the short and medium term, there are still benefits to be gained for a grains adviser participating in social media. These are:

- Access to information,
- network building; and
- online presence and reputation.

Access to information

For any adviser considering using social media, the most immediate benefit is accessing information from all your preferred information sources. We're now at the stage where almost all agricultural media organisations, seed, chemical, fertiliser and marketing companies as well as grower groups and government organisations have a social media presence and are using it to distribute information the minute it comes to hand. This allows recipients of this information to be more proactive and timely with decision making as you're not waiting for a specific publication date, by which time, the information will not be as useful. It also allows you to receive the information most relevant to you, instead of having to flick through an entire publication.

In addition to the information sources listed above, a growing number of producers are using platforms like Twitter to share what's happening on their farm, while seeking information from others in industry. This includes seeking agronomic advice and troubleshooting machinery issues.

What's becoming increasingly important as more and more individuals and organisations contribute content to social media, is the filtering of that information to ensure it's relevant and easily accessed. There are a number of mechanisms that allow you to organise social media content to ensure you only get information that is relevant to you.

In order to sort incidental information, you may want to use a social media manager such as Tweetdeck (for Twitter only) or Hootsuite (for Twitter and other platforms such as Facebook and LinkedIn). A social media manager allows you to sort tweets into columns according to people or topics you're interested in. Some twitter hashtags (a hashtag is a way of categorising tweets) you may want to follow include: #tweetsfromthetractorcab, #harvest13, #plant14, #ausag, #agronomy, #grdcupdates and #agchatoz.

If you're after specific information from a particular source, you can often alter your settings within various social media platforms to ensure you are alerted whenever new information becomes available. For example, I receive a text message to my phone any time my local Country Fire Authority Twitter account puts out information regarding an incident. Another mechanism for ensuring you're alerted when new information becomes available is Google Alerts (you need a Gmail account to use this). This will allow you to select keywords that interest you. When new content that contains those keywords appears online, you'll receive an email. You have the ability to choose the type of content received and the frequency of emails received. I have set several Google Alerts. Some of these include "Agricultural Apps" and "Social media in Australian Agriculture".

Network Building

As the amount of information available increases, so does the complexity of decision making. This means that, in the future, it will be unreasonable to expect that an individual adviser will be an expert in all areas. However, an individual will be expected to leverage on their professional and personal networks, to tap into people and resources that may be able to assist.

Local networks will always remain crucial, as producers will look to their adviser for issues relating to their region. However, as grain production is increasingly impacted by happenings on the other side of the state, country and even the world, building networks outside immediate geographic boundaries is important. Being involved in social media is a good way to start building those networks. In addition to accessing information, strong online networks can present professional opportunities and business leads.

For the Australian grains industry, following the hashtags mentioned above on Twitter is a great place to start networking with farmers, advisers, grain marketers, researchers, seed/chemical/fertiliser companies, industry bodies, agricultural media and consumers. Twitter is also useful for a global perspective, but you may also be interested in Google+. Google + has a series of communities centered on a common theme such as "Agricultural Innovators" and "Extension" that allow members to seek advice from professionals all around the world. Google + is free and accessable to anyone who has a Google account.

Online Presence and Reputation

Your professional reputation is an incredibly important asset. You work hard to ensure that you have a good presence in the area you service and that clients know to come to you with an issue that relates to your area of expertise. But what does your online presence look like?

If you don't have one; you need one. Increasingly, the Internet is the first place many people will visit when seeking information or looking for someone to help them. If you don't have an online presence, you run the risk of missing out on potential clients as well as business, media, career and funding opportunities.

Do you have a personal online presence instead of a professional one? Clean it up (no inappropriate photos or opinions); lock down your privacy settings for personal accounts so only those you choose can access it. Treat anything you post like a personal press release.

In addition to a Twitter and Google + presence, which allows you to network with others in your area of interest, consider a LinkedIn profile. This will allow you to have a 'virtual resume' as well as allow prospective clients, employees, employers or business partners to view not only your capabilities, but also your networks.

Conclusion

Social media is what you make of it. It can be used as entertainment or as a professional business tool, a time waster or a way of keeping up with the latest information. At present, return on investment from social media is difficult to calculate, particularly from an adviser's perspective, as often it's not used directly as a marketing tool. However, placing a value on access to information, networks and your reputation is also difficult, yet no one denies their importance in any business. Social media has the potential to aid these three areas, and will only become more important in the future as we move into a more online reliant workforce.

Please see the next page for a checklist of considerations when posting content on social media channels.

References

Cook, P. (2012) Keepad Evaluation from I.T. Starter Guide presentation, GRDC Farm Business Updates, Pineroo, Jamestown, Nhill, Echuca and Hamilton, October 2012.

Future Work Skills 2020. Institute for the Future for the University of Phoenix Research Institute, 2011.

The Do's and Don'ts of posting online

Do:

- ✓ Be human
- ✓ Be helpful and educating
- ✓ Ask questions
- ✓ Post consistently (try to stick to a few key themes)
- ✓ Respond to comments
- ✓ Post images and links
- ✓ Be relevant when joining conversations
- ✓ Maintain your account
- ✓ Understand your audience
- ✓ Pay attention to the reasons why you use different platforms
- ✓ Proofread your posts
- ✓ Remember that once it's online, it's permanent

Don't:

- ✗ Self promote excessively
- ✗ Post too often
- ✗ Pick fights and troll
- ✗ Give out personal information or too much information
- ✗ Post links you haven't read
- ✗ Drink and post!
- ✗ Post something you wouldn't want your mother to read

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Putting social media and new information communication technology to work

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AgriKnowHow

GRDC project code: IDA10447

Keywords

information communication technology, feedback collection systems, polling, Twitter, text messaging.

Take home messages

- **Social media is just one branch of the diverse range of information communication technology (ICT) tools available.**
- **ICT and social media help share information in real-time.**
- **There are many tools available that can help agronomists, presenters and farming systems groups quickly poll and collate feedback data.**
- **Currently, all free feedback systems reviewed require internet access for response gathering.**

Introduction

Social media covers a diverse range of applications and is just one branch of information communication technology (ICT). My interest lies in the use of social media and other ITC platforms to help deliver technical information and to collate feedback.

In this presentation I will explore some of the examples of the use of social media and ICT that I was exposed to during a GRDC Industry Development Award (IDA) and some of my on-going exploration of these tools.

In 2013, I was fortunate to receive a GRDC IDA to attend three international precision agriculture conferences and to learn how ICT was being used in other countries to deliver technical information.

As part of my IDA I visited CABI, an inter-governmental non-profit organisation set up by the United Nations. Part of CABI's remit is to deliver agronomic information to improve sustainable and profitable farming practices in developing countries.

While most farmers in developing countries don't have smart phones, about 60 per cent do have basic mobile phones. These are being used as important conduits for delivering timely, relevant information.

Here are two examples that I learnt from CABI, which might trigger ideas about how we could do things differently in Australia.

Agronomists using Twitter

I was told of several agronomists in developing countries who are using Twitter to help service large numbers of clients. Each client is set-up with a Twitter account and this platform is used for messages to be sent to all clients as one. It enables all clients to see the questions and replies arising from initial information.

Compared to sending multiple texts through a telco, using Twitter is cheap, it engages large numbers of farmers to learn from each other's discussion but it probably would not suit private agronomists. However, a similar more elite system could be established using group messages in an application (app) such as Viber. Setting up a Google Circle could be another option.

Farmer SIM card

The second example relates to a project called direct to farmers (D2F - direct2farm.org/). This project is using mobile phone technology, social media etc to deliver agri-extension. As part of this, CABI has helped establish a relationship between a telco and a fertiliser company in India.

The telco has created a 'farmer SIM card'. When a farmer buys this phone package they are added to a database and receive daily voice messages (not texts because of literacy) from an agronomist. Each call centre manages about 40,000 farmers and a total of 4 million farmers are involved in the program. In addition, the farmers have phone contact with this agronomist for free advice that provides more detail than the voice message and answers their specific issues.

Survey and feedback tools

As virtually every grower will have a mobile phone, I have started to investigate their use as devices for gathering feedback at field days. While I am yet to find a simple free system that does what I want, I have found many other apps that could be of use for gathering and sharing information.

Table 1 details some of the products at which I have looked so far. This is by no means a comprehensive review and I encourage those interested in using these tools to keep searching as new products will keep appearing.

I found the web forum www.freetech4teachers a useful resource. While not specifically for gathering feedback it provides new technology suggestions for teachers but some are relevant for workshops and presentations.

Through this site I found Socrative (www.socrative.com) which is a free educational tool that could be used as a method of sharing information with clients and challenging clients through quizzes etc.

If participants need a password/account code to log into the survey these could be sent to them all via Twiitter if they are signed up. Alternatively, converting the link to a QR code that is published in the field day book, or on a paddock sign, that can be scanned would be another way to take respondents to the feedback survey.

The Ag Excellence Alliance Social Media project produced a series of fact sheets that detail the steps in setting up social media accounts, details can be found at http://agex.org.au/project/social-media-project/

Table 1. Overview of 10 on-line, mobile feedback and or survey products

Product	What it can do	What you get for what
Mentimeter www.mentimeter.com	• Mentimeter allows you to use mobile phones or tablets to vote on any question you specify. • Needs internet connection, to vote, each survey provided with unique entry code for voters. Logs answers live on screen. • Suited to workshops or field days. • Participants are sent a link.	• Free but need to subscribe if you want to collate data. • Single question voting. • Unlimited number of questions and respondents, no app required. • Powerful visualization in real-time.
Doodle Poll www.doodle.com	• Simplifies group scheduling, organising meeting dates. • However if you use free text entry rather than calendar entry you can create yes no questions. • Participants are sent a link.	• Free, account not required but helps with distribution as then links to e-mail contacts. • No app required.
Survey Monkey www.surveymonkey.com	• Results collate and comeback in real time. • Participants are sent a link. • Simple to use.	• Free version. • 10 questions per survey, 100 responses per survey. • No app required. • Subscription allows branded surveys.
Keepad Interactive www.keepad.com	• TurningPoint is Keepad Interactive's Audience Response Systems. • ResponseWare turns mobile devices and laptops into a virtual ResponseCard®, so no need for PowerPoint etc.	• Free software but need ResponseCard® keypads. • Android and IOS and Blackberry. • Needs internet connection.
Poll Everywhere www.polleverywhere.com	• Allows you to use all smart phone platforms, twitter or web browser to vote. • You can moderate responses. • Replaces audience sending text messages.	• Free version, 40 responses per poll, 1 user per account.
www.feedbackferret.com	• A sophisticated feedback management tool that enables businesses to identify their customers' likes and dislikes, and what really drives customer satisfaction. • Use this customer insight to improve customer experience and profitability.	• Not clear
Poll to Go http://polltogo.com/info/	• Instant audience feedback. • Only appears to be for IOS. • Voting can also be done through scanning QR codes.	• Sign-up for free.
Textit LIVE Textit.com.au	• Publish live text questions and comments on the big screen. • Run Y/N SMS polls and multiple choice questionnaires. Engage your audience via SMS. • All inbound text message data is downloadable as a spread sheet for profiling/mining.	• All textit products (excluding textit LIVE, below) are $50/month each (ex gst) and include a single-use Virtual Mobile Number. • No charge for inbound messages. • No contract period. Messages/month — Cost per SMS (ex gst) 1 – 999 — 17c 1,000 - 10,000 — 16c 10,001 - 20,000 — 15c 20001 - 50000 — 13c 50001 + — 10c
Aviusinsight.com/technologies-sms	• Looks like a higher end survey product. • Allows customers to SMS general or targeted feedback. • Does use QR codes to quickly link to a site.	• On request.
Adobe-e-forms and Adobe testing and targeting http://www.adobe.com/au/solutions/testing-targeting.html Adobe social	• Digitally fill in forms. Create new forms and convert old ones. • Market research tools. • Social media management and linking to market research.	• Visit website.

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New canola varieties for 2014

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Keywords

canola, varieties, 2014

Take home messages

- **Check NVT results and the blackleg management guide to make the best decisions about new varieties.**
- **Select the most appropriate herbicide group based on your weed spectrum.**
- **Use varieties with high levels of blackleg resistance, especially in medium to high rainfall zones.**

Once again, there is a large number of new canola varieties available for 2014. There are several new open pollinated varieties being released which will attract an end point royalty (EPR). However, the majority of new releases will be hybrids. These, together with a range of existing varieties, will give growers and advisers a wide selection of varieties across all herbicide tolerance groups for planting in 2014.

Blackleg and other diseases

Blackleg has the potential to be a very destructive disease when growing canola. Its management is critical in order to maximise yields. Growers and advisers are directed to the Blackleg Management Guide (at grdc.com.au or australianoilseeds.com) as a point of reference to help manage the disease. The guide is updated annually in March.

It is important to review and monitor blackleg management strategies on a regular basis as the disease has a high capacity to breakdown varietal resistance.

Blackleg management involves assessing risk to the disease (based on rainfall and the intensity with which canola is grown on a regional level), having a good understanding of disease levels in existing and previous crops, and then planning to keep new canola crops at least 500 meters from the previous year's canola stubble. Additional management strategies include selecting varieties with a suitable blackleg resistance rating, assessing the need to use fungicides and possibly changing varieties to a different blackleg resistance group after a number of years of growing one variety.

Since 2011, NVT trials have been sown with the same fungicide treatment on all varieties and so the reaction to blackleg will be more difficult to assess from looking at the trials.

Much higher than normal occurrences of downy mildew and white leaf spot were reported across Australia in 2013. Any varietal differences and effects these diseases are having on yield are not clear at this stage and will be the subject of on-going research.

Speciality and juncea types

In recent years a number of specialty canola varieties have been released. These include the Victory® varieties marketed by Cargill and Monola® varieties marketed by Nuseed. These varieties have a different oil profile, than commodity canola, that is more suitable for use in the food industry. Agronomically, speciality canola is the same as commodity canola. Speciality canola is being offered to growers in a closed loop marketing systems, often attracting a premium price. Currently production contracts for these varieties are limited to particular regions close to crushing plants, but this may change into the future.

Juncea canola is being developed as a drought and heat tolerant alternative to canola for the low rainfall environments. In 2014 there will be two juncea varieties available for sowing, both marketed by Seednet. Sales of juncea canola must be segregated from regular canola.

Varietal selection

The selection of the most suitable canola variety for a particular situation need to consider maturity, herbicide tolerance, blackleg resistance, relative yield, oil content and early vigour.

The weed species expected may dictate the need for a herbicide tolerant production system, such as triazine tolerant, Clearfield® or Roundup Ready®. A triazine tolerant variety will incur a yield and oil penalty when grown in situations where they are not warranted.

When decisions are being made on canola varietal choice, the National Variety Trials (NVT) provide an excellent, unbiased resource. Data from the NVT website (www.nvtonline.com.au) and any observations you might make from trials in 2013 will greatly add to the confidence you have when selecting a new variety.

Varietal characteristics for new varieties for 2014

Notes on a newly released conventional variety

Nuseed Diamond (tested as NHC1203C). Early-mid maturing hybrid. Current blackleg rating of R-MR (P). Medium plant height. Tested in NVT in 2012-13. Bred and marketed by Nuseed Pty Ltd.

Herbicide tolerant varieties

Notes on newly released Clearfield® (imidazolinone tolerant) varieties

Hyola® 577CL. Mid maturing hybrid. Very high oil content. Very high yield, medium-tall plant height. Adapted to medium-high rainfall areas. Pacific Seeds suggest a blackleg resistance rating R-MR (P). Rotation blackleg group to be advised. Tested in NVT in 2013. Pacific seeds indicate excellent for standability and direct harvesting. Bred and marketed by Pacific Seeds.

Pioneer® 44Y87 (CL) (tested as Pioneer 09N121I). Early-mid maturing hybrid. Moderate-high oil content. Medium plant height. Suited to medium rainfall areas. Current blackleg resistance rating MR (P). Tested in NVT in 2012-13.

Pioneer® 45Y88 (CL) (tested as Pioneer 09N146I). Mid maturing hybrid. Moderate-high oil content. Medium plant height. Suited to high rainfall and irrigated areas. Current blackleg resistance rating MR (P). Bred and marketed by DuPont Pioneer.

XCEED™ X121 CL. The first hybrid Clearfield® tolerant juncea canola. Four days later than EXCEED™ Oasis CL. Excellent early vigour and branching ability and has high oil content. EXCEED ™ X121 CL has excellent pod shattering tolerance and is suitable for direct harvest. Provisional blackleg resistance of R-MR. Bred by Seednet in conjunction with GRDC.

Notes on newly released Triazine tolerant (TT) varieties

ATR Bonito⫯ (tested as NT0183). Early-mid season maturing variety. Short-medium height. Current blackleg rating of MR (P). Tested in NVTs in 2012-13. Bred and marketed by Nuseed. An EPR of $5 per tonne (GST ex) applies to ATR Bonito⫯.

ATR Wahoo⫯ (tested as NT0184). Mid maturity variety. Medium plant height. Current blackleg rating of MR (P). Tested in NVTs in 2012-13. Bred and marketed by Nuseed. An EPR of $5 per tonne (GST ex) applies to ATR Wahoo⫯.

Hyola® 450TT. Early to mid-maturing hybrid. Medium plant height. Provisional blackleg resistance rating of R (P), blackleg rotation group D. Pacific Seeds indicate excellent standability and shatter tolerance. Tested in NVTs in 2013. Bred and marketed by Pacific Seeds.

Hyola® 650TT. Mid to mid-late maturing hybrid. Medium-tall plant height. Provisional Pacific Seeds blackleg resistance rating of R (P). Pacific Seeds indicate excellent standability and shatter tolerance. Tested in NVTs in 2013. Bred and marketed by Pacific Seeds.

Monola™ 314TT. Early-mid open-pollinated specialty oil variety. Medium plant height. Nuseed indicate a blackleg rating of MR. Bred and marketed by Nuseed.

Pioneer Sturt TT. Early-mid maturity open-pollinated variety. Moderate oil content. Short-medium plant height. Adapted to the low and medium rainfall areas. Blackleg rating of MS-S. Tested in NVTs in 2011-13. An EPR applies. Bred by Canola Breeders but marketed by DuPont Pioneer.

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Notes

Testing retained sowing seed of hybrid canola over a range of rainfall zones

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GRDC project code: YCR00001

Keywords

canola hybrids, retained seed, yield, quality

Take home messages

- **Average yield loss of canola grown from retained hybrid seed varied from site to site, but ranged from 7 to 17 per cent when compared to the commercial hybrid sowing seed.**
- **Oil content of crops grown from retained hybrid seed was significantly lower than that from commercial hybrids.**
- **While some hybrids were less affected by using retained seed it is recommended that new seed is purchased each year.**

Background

Canola hybrids are now available in Australia covering conventional, Clearfield®, triazine tolerant and Roundup Ready® herbicide systems. As farmers are used to sowing retained seed from open pollinated crops, they may wish to retain sowing seed harvested from the previous hybrid crop to reduce the up-front cost of sowing a canola crop. Little independent research has evaluated the effect on plant growth, blackleg resistance and grain yield. It is important that farmers have credible information as to the effect of retaining hybrid seed in all rainfall zones.

Recent on-farm research

On-farm research has previously been conducted as part of the Better Oilseeds project, but only based on one hybrid variety. This research showed a reduction in blackleg resistance in the retained hybrid seed but variable grain yield responses. Additional research conducted by Pacific Seeds showed significant yield reductions by retaining hybrid seed. This research, however, only tested Pacific Seeds hybrids and used seed harvested from yield plots and so would be expected to have some contamination from previously harvested plots.

This preliminary work highlights a need for further on-farm research to determine the effect of retaining hybrid sowing seed on plant growth, blackleg resistance and grain yield for the range of herbicide tolerance options over a range of rainfall zones in southern Australia.

Research objective

This research program aimed to conduct a series of trials in 2012 to measure the effect of retaining hybrid sowing seed on plant growth, blackleg resistance and grain yield compared to the original hybrid (ie. as purchased from seed supplier; referred to as 'commercial' here after) for a range of herbicide tolerance options in a range of rainfall zones in southern Australia.

Methodology

Replicated trials were conducted at four locations in different rainfall zones in the South Australia. Site locations were Minnipa and Lameroo for low rainfall, Bordertown for a medium rainfall and Bool Lagoon for high rainfall conditions. Plot size was 10 meters long by eight rows and three replicates were sown. Trials were conducted to compare the original hybrid seed with first generation farmer retained hybrid seed. Retained hybrid sowing seed was sourced from individual farmers commercial crops from 2011 to reduce the possibility of contamination in samples harvested from small plot yield trials.

Conventional (Hyola® 50 plus CB™Taurus at Bool Lagoon), Clearfield (Pioneer®45Y77, 45Y82, 46Y83 and Hyola® 575CL) and triazine tolerant (CB™ Tumby HT® and CB™ Jardee HT®) hybrids were assessed. All seed was graded and assessed for germination to ensure good quality seed was used. Treatments under test were the retained hybrid seed plus and minus a fungicide treatment compared to the original hybrid seed also plus and minus a fungicide treatment. Varieties with the same herbicide tolerance were sown in groups to reduce the risk of damage by herbicides.

Plant vigour, internal blackleg infection, grain yield and oil content were measured.

Results

Flowering dates

Very little variation occurred for flowering date between the commercial hybrid and the retained sowing seed with only about one day difference in days to 50 per cent of plants having first flowers.

Early vigour

Some hybrids showed reduced early vigour when sown with retained seed but the response was variable.

Blackleg

Internal infection with blackleg was scored at three sites. A significant interaction between hybrid and seed type occurred at Lameroo and Bordertown with no significance at Bool Lagoon (Table 1). Several hybrids showed increased internal infection when sowing seed was retained.

When hybrid seed was retained Jockey® was needed to be applied to get a similar low level of blackleg as that produced by the commercial hybrid seed, except at Bordertown where very high levels of blackleg occurred (Table 2).

Grain yield

Grain yield was significantly higher for commercial over retained hybrid sowing seed at all sites except Bool Lagoon (Table 3), with the greatest percentage yield loss at the two lower rainfall sites of Minnipa and Lameroo. Overall, yield loss ranged from 7 to 17 per cent over all hybrids. A similar level of yield loss from three hybrids was shown at Hart in 2013 (Table 6).

Table 1. Internal blackleg infection (%) at three sites in 2012

Lameroo								
	45Y77	45Y82	46Y83	Hyola50	Hyola575CL	CB Jardee HT	CB Tumby HT	
Commercial	20.7 e	12.1 c	8.4 c	1.8 a	5.5 b	21.8 de	22.8 de	
Retained	21.4 de	27.5 e	13.1 c	8.4 b	4.2 b	24.1 e	17.5 d	
Bool Lagoon								
	45Y77	45Y82	46Y83	Hyola50	Hyola575CL	CB Jardee HT	CB Tumby HT	Taurus
Commercial	19.4	17.7	8.7	1.5	4.1	28.5	38.9	3.0
Retained	21.5	22.7	9.1	7.3	4.7	27.8	34.1	4.0
Bordertown								
	45Y77	45Y82	46Y83	Hyola50	Hyola575CL	CB Jardee HT	CB Tumby HT	
Commercial	68.5 f	54.6 e	46.5 d	4.8 a	9.9 b	87.5 g	96.8 h	
Retained	71.8 f	57 e	60.3 e	24.6 c	12.8 bc	86.8 g	94.9 gh	

Note: Within table, values followed by a different letter are significantly different.

Table 2. Internal blackleg infection (%) affected by seed type and fungicide at three sites in 2012

Treatment	Lameroo		Bordertown		Bool Lagoon	
	Jockey	Nil	Jockey	Nil	Jockey	Nil
Commercial	10.9 a	15.7 b	47.5 a	57.9 b	13.3 a	17.2 b
Retained	12.6 a	20.6 c	57.2 b	57.7 b	16.3 ab	16.5 ab

Note: Within table for each site, values followed by a different letter are significantly different.

Table 3. Mean grain yield (t/ha) for hybrid sowing seed in 2012

Site	Commercial kg/ha	Retained kg/ha	% Commercial %
Bool lagoon	2.39 a	2.23 a	93
Bordertown	1.66 a	1.50 b	90
Lameroo	0.83 a	0.69 b	83
Minnipa	0.57 a	0.48 b	85

Note: Within table for each site, values followed by a different letter are significantly different.

Table 4. Grain yield of retained hybrid compared to commercial sowing seed for different varieties at all sites (%)

Variety	% Commercial variety			
	Bool lagoon	Bordertown	Lameroo	Minnipa
1	94	89	85	107
2	100	90	85	80
3	91	93	80	80
4	82	82	84	78
5	92	83	71	75
6	99	106	86	96
7	101	94	95	94
8	88			

Table 5. Grain yield (t/ha) of retained and commercial hybrids as affected by fungicide at all sites 2012

Seed type	Lameroo		Minnipa		Bordertown		Bool lagoon	
	Fungicide	Nil	Fungicide	Nil	Fungicide	Nil	Fungicide	Nil
Commercial	0.83 a	0.82 a	0.56 a	0.58 a	1.68 a	1.66 a	2.44 a	2.35 a
Retained	0.71 b	0.68 b	0.47 b	0.49 b	1.53 a	1.47 b	2.31 a	2.15 b

Note: Within table for each site, values followed by a different letter are significantly different.

Table 6. The grain yield (t/ha) of three canola varieties, from commercial, retained or mixed seed at Hart in 2013

Treatment	Grain yield (t/ha)		
	Hyola 50	CB Tumby HT	45Y82
Commercial + Jockey	1.73 a	1.08	1.59 a
Retained + Jockey	1.38 bc	1	1.35 c
Commercial/Retained Mix + Jockey	1.56 ab	1.04	1.47 ab
Commercial	1.73 a	1	1.58 a
Retained	1.33 c	0.97	1.41 bc
Commercial/Retained Mix	1.49 bc	1	1.48 ab
l.s.d. ($p \leq 0.05$)	0.21	NS	0.12

Note: Within table, values followed by a different letter are significantly different.

Can you use a mixture of commercial and retained hybrid seed?

One means of reducing the cost of sowing seed would be to use a mixture of commercial and retained hybrid sowing seed. A mixture of 33 per cent commercial seed and 66 per cent retained seed was tested at Hart, SA in 2013 (Table 6).

While grain yield of CB™ Tumby HT® was not significantly affected by using retained seed or mixtures compared to the commercial sowing seed, the grain yield of the mixture was similar to that of the commercial hybrid for Pioneer® 45Y82, with and without Jockey®, and Hyola® 50 with Jockey® (Table 6).

Grain quality

Oil content of canola was significantly reduced when retained seed was used at all three sites tested (Table 7). However, protein content was not affected by retaining sowing seed compared to the commercial hybrids and glucosinolate content was only affected by retaining sowing seed at Bool Lagoon and in this case the variation was very minor compared to the acceptable limits for canola quality.

Table 7. Oil content of commercial and retained hybids in 2012

Site	Oil %	
	Commercial	Retained
Bool lagoon	46.0 a	45.4 b
Bordertown	42.3 a	41.6 b
Lameroo	40.1 a	39.2 b

Note: Within table for each site, values followed by a different letter are significantly different.

Financial returns from using retained hybrid sowing seed compared to commercial hybrid seed

Relative financial returns were calculated based on a price per tonne of $600. Oil content calculated at the normal contract basis resulted in the grain from the commercial hybrid producing a premium of about $6 per tonne over the retained grain. Likewise the cost of preparing retained sowing seed ready for sowing was calculated at $6 per hectare, graded, treated with fungicide and bagged.

As can be seen from Table 8, the use of commercial hybrid sowing seed gave a good financial return over the use of retained hybrid seed for most

Table 8. Difference in $ return from commercial and retained hybrid sowing seed for each variety at all four sites in 2012

Variety	Increased $ return per ha of using commercial over retained hybrid sowing seed (@ $600 per tonne)			
	Bool lagoon	Bordertown	Lameroo	Minnipa
1	73	94	71	-16
2	-1	115	87	89
3	120	68	102	70
4	290	228	81	96
5	131	193	147	104
6	12	-56	64	11
7	-10	49	24	14
8	180			

hybrids at most sites. Using a price of $26 per kg for hybrid seed and a sowing rate of 2.5 kg/ha the difference in returns of over $65 per hectare produces a benefit to using commercial seed. Oil content premium and grading and fungicide cost reduced this threshold by $12 per hectare and $18 per hectare when grain yield could be expected to be 1 and 2 t/ha respectively.

Summary

In many cases higher grain yields and reduced impact of blackleg occurred when commercial hybrid sowing seed was used rather than retained hybrid sowing seed. Benefits of commercial hybrid sowing seed outweighed the cost of buying that seed. Differences between hybrids are likely to be caused by the hybrid breeding system being used by the different companies and the degree of heterosis between parental lines that are used to produce each hybrid.

Similar results have been shown in recent studies in Canada where a yield reduction of up to 13 per cent has been shown for retained hybrid canola seed.

Perhaps mixtures of commercial and retained sowing seed may be used to reduce the cost of sowing seed while still obtaining reasonable grain yields. However, this needs to be further investigated with more hybrid varieties and sites before good conclusions can be drawn.

Acknowledgements

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South Australia

Grains Research UPDATE

Students at work

Field Peas App

GRDC
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***Field Peas*: The Ute Guide** app will assist in recognising disease, insect attack and poor nutrition symptoms in field pea crops. Also contains best practice in growing and marketing the crop.

Application features:

- Predictive search for topics
- Progressive Symptom Sorter to identify disease or physical, nutritional or chemical disorders and their management
- Compare photos of field pea disorders or pests side by side with pictures in the app
- Opt to download content updates in-app to ensure you're aware of the latest research on field peas
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Evolution of herbicide resistance in Barley grass (*Hordeum glaucum Steud.*) populations across cropping systems of South Australia

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School of Agriculture, Food & Wine, The University of Adelaide

GRDC project code: UA00134

Keywords

herbicides, resistance, survey, barley grass

Take home messages

- **We have reported the first cases of group A and B herbicide resistance in *Hordeum glaucum* in South Australia**
- **There are limited post-emergent herbicide options for the control of barley grass in crops. With the evolution of resistance to group A and B herbicides, barley grass control will become very difficult.**
- **Resistance to Group A herbicides in barley grass is associated with mutations in the target-site.**

Introduction

Barley grass (*Hordeum* spp.) is a problematic weed that has been reported to be increasing in abundance in cropping systems in South Australia. It has been observed that management practices used in cropping systems in SA have selected highly dormant *H. glaucum* populations, which defer establishment until after the crops have been planted. Earlier, non-dormant populations of barley grass could be easily controlled with the use of knockdown herbicides applied in late autumn. This change in weed biology may have contributed to increased reliance on post-emergent herbicides for barley grass control in broadleaf crops. Previous research in SA had reported resistance to Group A (ACCase inhibiting) herbicides in *H. leporinum*. Current research undertaken at The University of Adelaide has confirmed the development of herbicide resistance in *H. glaucum* populations to

Group A and B (ALS inhibiting) herbicides. In this paper we will report results of studies conducted to investigate the evolution of herbicide resistance in *H. glaucum*.

Herbicide resistance to Group A and B herbicides

Screening and dose response experiments were conducted, which have identified populations with varying levels of resistance to several Group A herbicides. Dose response studies have confirmed populations to be resistant to Targa® (quizalofop), Verdict® (haloxyfop) and cross resistant to Select® (clethodim). The repeated exposure of these populations to group A herbicides has resulted in the evolution of high levels of resistance (Figure 1). Sequencing of carboxyl-transferase (CT) domain of the ACCase gene from resistant plants confirmed target-site resistance as the mechanism of herbicide resistance. Sequencing from resistant plants confirmed the presence of previously known mutations at position 1781 in 5 populations and 2078 in other 2 populations.

Following the confirmation of herbicide resistance in these populations, a random field survey was conducted to collect barley grass populations from the Upper North (UN) and Eyre Peninsula (EP) regions of SA in October 2012. Populations were randomly collected from cropping fields, pastures, scrub and fence lines. A total of 108 sites were sampled, but only 92 populations had enough seed to form a representative sample. In the following season, the populations were screened for herbicide resistance with Group A - Targa® and Group B - Raptor® (imazamox) and Intervix® (imazamox+imazapyr) herbicides at field rates. Survival assessments were taken at 28 days after application. Populations with greater than 20% plants surviving herbicide application were classified as resistant, whereas populations with 1 to 20% plant survival were classified as developing resistance. Where all plants were killed by the herbicide treatment, the population was classified as susceptible.

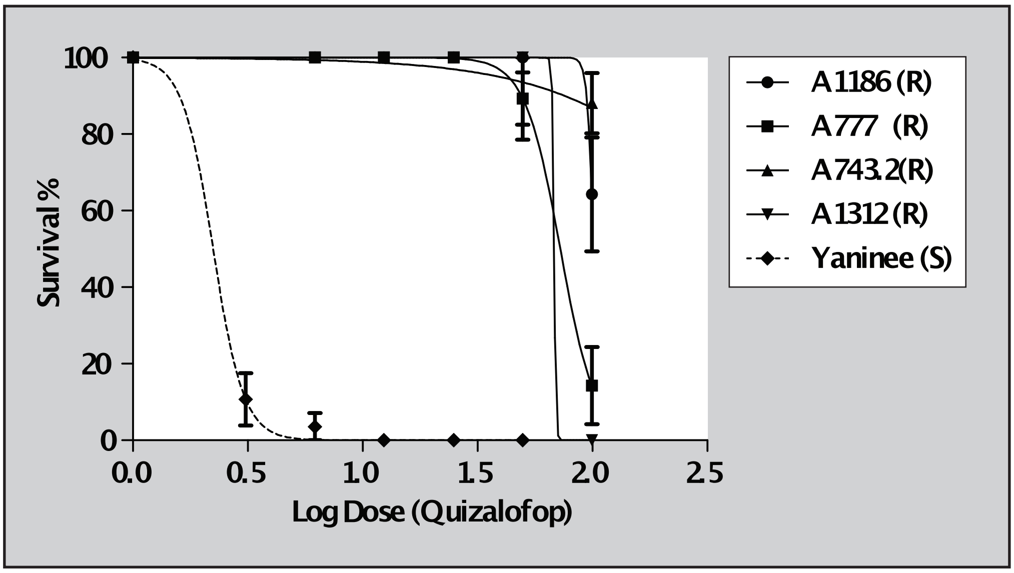

Figure 1. Effect of quizalofop on the survival of barley grass populations across SA and the susceptible population from Yaninee.

Table 1. Percentage of paddocks with Group A resistant barley grass in cropping regions of SA

Resistance Classification	% Survivors	Number of populations			% of populations		
		UN	EP	Total	UN	EP	Total
Resistant	> 20	5	2	7	24	3	8
Developing resistance	1 – 20	5	2	7	24	3	8
Subtotal		**10**	**4**	**14**	**48**	**6**	**15**
Susceptible	0	11	67	78	52	94	85
Total		21	71	92			

Table 2. Percentage of paddocks with Group B resistant barley grass in cropping regions of SA

Resistance Classification	% Survivors	Number of populations			% of populations		
		UN	EP	Total	UN	EP	Total
Resistant	> 20	0	0	0	0	0	0
Developing resistance	1-20	0	4	4	0	6	4
Subtotal		**0**	**4**	**4**	**0**	**6**	**4**
Susceptible	0	21	67	88	100	94	96
Total		21	71	92			

Across the surveyed area, 15% of the fields tested had a barley grass population with some level of resistance to Targa® (Table 1). As expected, there was a large variation in the percentage of resistant populations between the two regions. In UN region approximately half (48%) of the populations tested had some level of resistance, whereas, only 6% populations from EP exhibited some level of resistance to Targa®. Herbicide resistance was detected in samples collected from fields under crop (11 populations) and pasture (three populations), but cropped fields had a greater frequency of resistance.

Out of the 92 randomly collected populations tested with Raptor® and Intervix®, approximately 4% exhibited low level of resistance to group B herbicides (Table 2). All of the populations with Group B resistance were collected from the EP. Three of these Group B resistant populations were collected from wheat crops; in two paddocks there was a heavy infestation of barley grass but barley grass density was low in the third paddock. The fourth population came from a paddock sown with barley with thick patchy distribution of barley grass. Widespread adoption of Clearfield™ technology has increased reliance on group B herbicides in local cropping systems, which may lead to greater occurrence of resistance to this herbicide group.

Acknowledgements

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Notes

The competitive position of Australian grains in SE Asian markets - 5 years after deregulation

Dr. Soon-Bin Neoh,
Soon Soon Group of Companies

Keywords

wheat, soybean, lupin, canola, competitiveness, noodles, biscuits, bread, health, deregulation.

Take home messages

- **Australian wheat has become more competitive in SE Asia after deregulation.**
- **Quality of Australian wheat in containerised shipments has deteriorated post deregulation.**
- **Black Sea wheat can be competitive in price and quality at certain times of the season.**
- **Demand for canola oil and meal is increasing in SE Asia. Australian canola can be competitive in price and quality but Black Sea canola can be attractively priced at certain times of the year.**
- **25 per cent of the world consumption of soy foods is in SE Asia. Certain varieties of Australian soybeans can perform well in soy milk and tofu when compared with Canadian and US soybeans.**
- **With the World Health Organisations current programme of reducing non-communicable diseases (NCDs) by 25 per cent by 2025, lupins have a potential to be incorporated into Asian food products.**
- **Dehulled lupin meal can replace soybean meal in poultry and swine feed.**

Abstract

Australia is in close proximity to SE Asia and has traditionally supplied much of the wheat requirements of the region. However, North America supplies most of the spring wheat used in bread making. Indian and Pakistani wheat, when competitively priced, can replace ASW/APW in biscuit and general purpose applications but SE Asian millers don't like the quality.

Recently, increased production of wheat in the Black Sea region has resulted in Black Sea wheat becoming more competitively priced, especially when shipped in containers. Black Sea wheat is available in low and high protein varieties which can replace ASW/APW and AH/APH respectively. The quality of Black Sea wheat is acceptable but availability is seasonal and prices will increase after the initial harvest period.

The use of North American spring wheat is preferred in sponge and dough bread making which predominates in the region. To date, neither APH nor AH has been able to capture a significant share of this market. However, new varieties like EGA Kidman shows promise. Deregulation of the single desk increased the number of wheat sellers which helps to make Australian wheat more competitively priced. However, quality and supply chain problems have emerged especially for containerised shipments. There is a need for a centralised export quality inspection service to ensure Australian wheat quality is maintained for exports.

The consumption of canola oil is increasing in the region, and increasing poultry and pig production has resulted in a large quantity of soybean meal being imported. This gives an opportunity for the local crushing of canola in the region where canola meal can partially replace soybean meal. In general, Australian canola is good quality, but again there is competition from Black Sea canola.

The SE Asian region accounts for 25 per cent of the world's soy food consumption. Annually, 3.5 million tonnes of food soybean is used to produce soy milk, tofu, tempe etc. The main suppliers are Canada and USA. Australia has the potential to supply the top end of this market. Our own evaluation shows that certain varieties of Australian soybeans can perform well in soy milk and tofu.

The region imports soybean meal as the main protein supplement for poultry and swine feeding. Australian researchers have shown that lupin is an excellent protein supplement for aquaculture and ruminant animals. Our own research shows that with proper processing, lupins can also replace soybean meal in poultry and swine feeding without growth performance penalties. The recent initiative by the World Health Organisation (WHO) on reducing Noncommunicable diseases (NCDs) by 25 per cent by 2025 should offer opportunities for the use of lupin as a nutraceutical supplement in Asian food products. Besides being able to lower postprandial blood sugar levels, lupin is also useful for the potential prevention of cardiovascular diseases. Lupin flour can be used in Asian food products such as noodles, bread, biscuits and sausages to increase fibre and protein contents.

Australian wheat will continue to be competitive into SE Asia but there is a need for better export quality control especially for containerised shipments. The formation of a centralised export inspection service and the setting up of a centralised product development centre will enhance the competitiveness of Australian wheat. Having a timely centralised annual crop report will also help. Besides wheat, Australian canola, lupins and soybeans also have tremendous potential in SE Asian food and animal feeds.

1. Competitive trade position of Australian wheat in SE Asia post deregulation

Australia is in close proximity to SE Asia and traditionally supplies most of the wheat requirements of SE Asia. However, deregulation of the single desk has changed the dynamics of the Australian wheat trade as many new smaller trading companies have emerged to compete with the Australian Wheat Board, Graincorp and CBH. Containerised shipments have also increased dramatically and the numbers of buyers of Australian wheat have also increased significantly. The benefit of a free market for wheat includes increased sales of Australian wheat to SE Asia and decreased sales to the Middle East due to logistics cost favouring SE Asia.

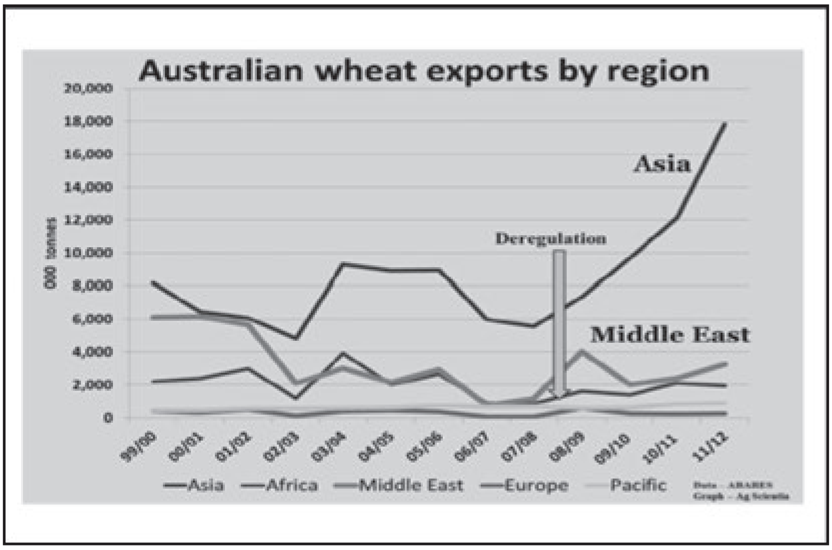


Figure 1. Australian wheat exports by region.

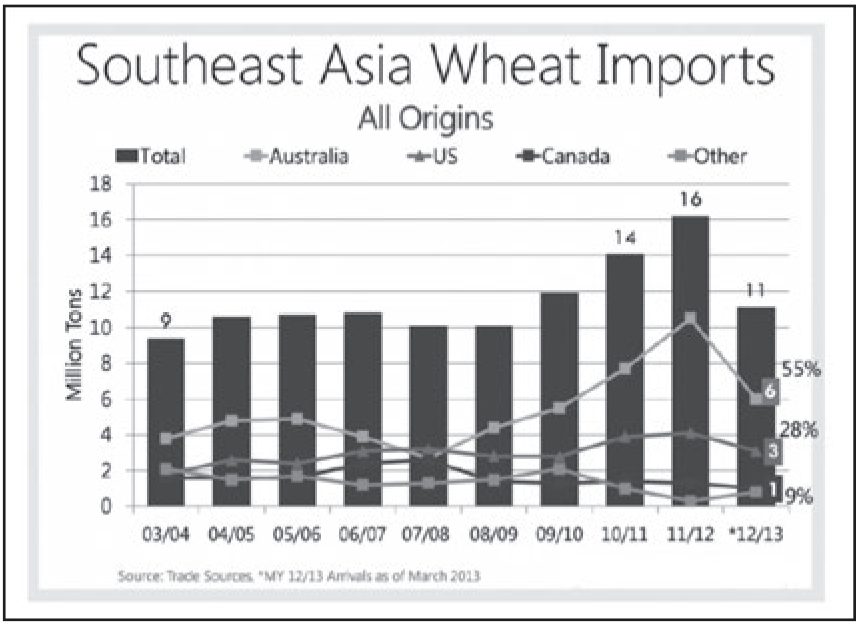


Figure 2. Southeast Asia wheat imports.

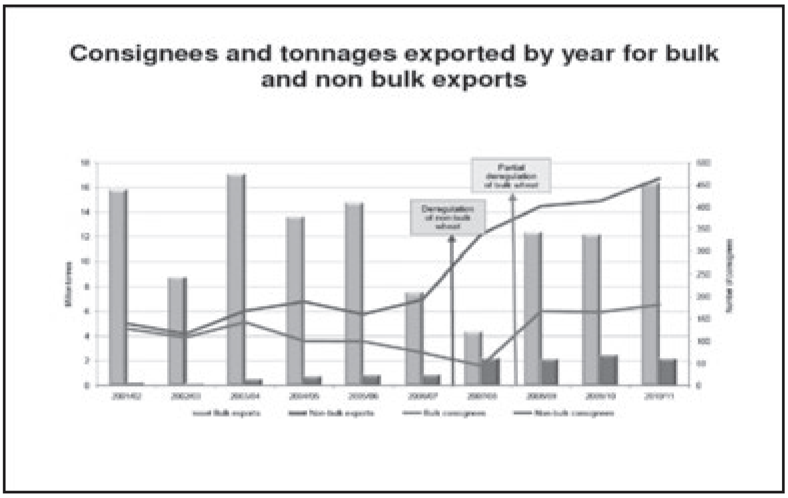


Figure 3. Tonnages exported by year for bulk and non bulk.

In recent years, increasing export availability from the Black Sea and Commonwealth of Independent State (CIS) countries has made wheat, especially in containers, competitive into SE Asia at certain times of the year.

In general, freight spreads favour Australian wheat over North American wheat into SE Asia. HRW is not competitive versus ASW/APW, but soft wheat like WW/SWW/SRW is replacing Australian soft wheat which is getting difficult to find. Nevertheless, even in years when North American spring wheat trades are at a big premium over APH/AH, SE Asian millers are still forced to import spring wheat for use in bread making due to the predominance of the sponge and dough method for making bread.

Indian and Pakistani wheat are available sporadically and despite being competitively priced over Australian wheat, they are not preferred in SE Asia due to poor quality and high foreign matter contamination.

From Figures 6 to 8, we can conclude that Black Sea wheat in containers can be discounting Australian wheat of an equivalent quality by more than USD50 per MT at certain times of the season.

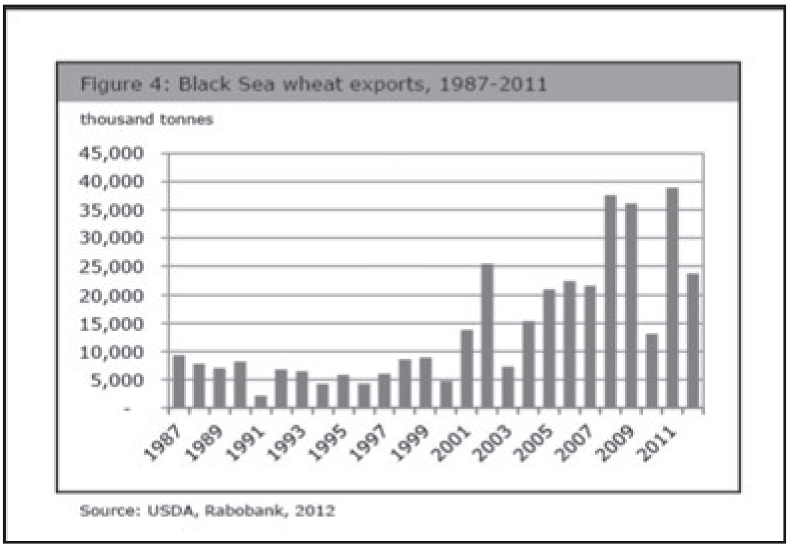


Figure 4. Black Sea wheat exports.

Figure 5. Net changes in world wheat trade for major exporters.

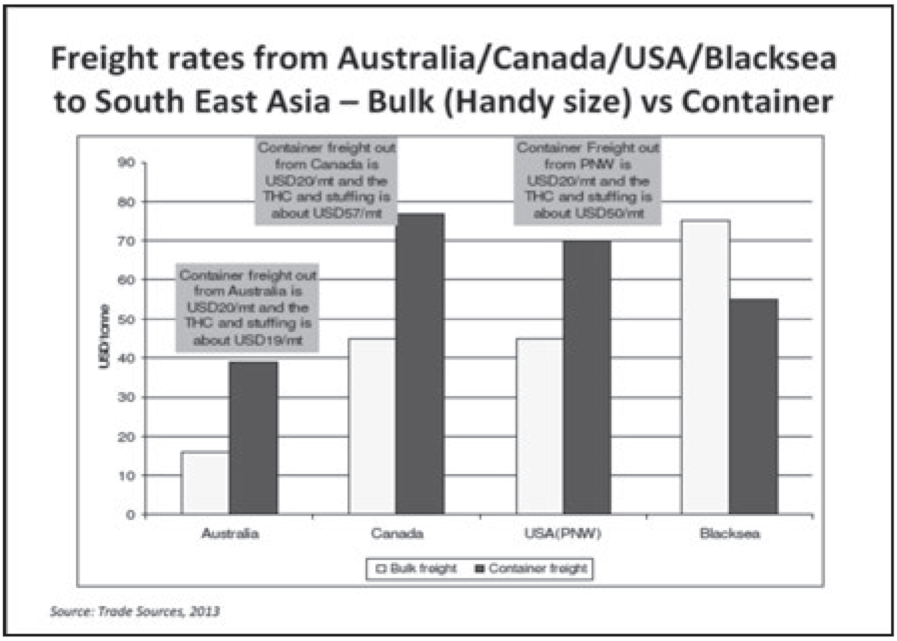


Figure 6. Comparison of bulk vs container freight rates by region.

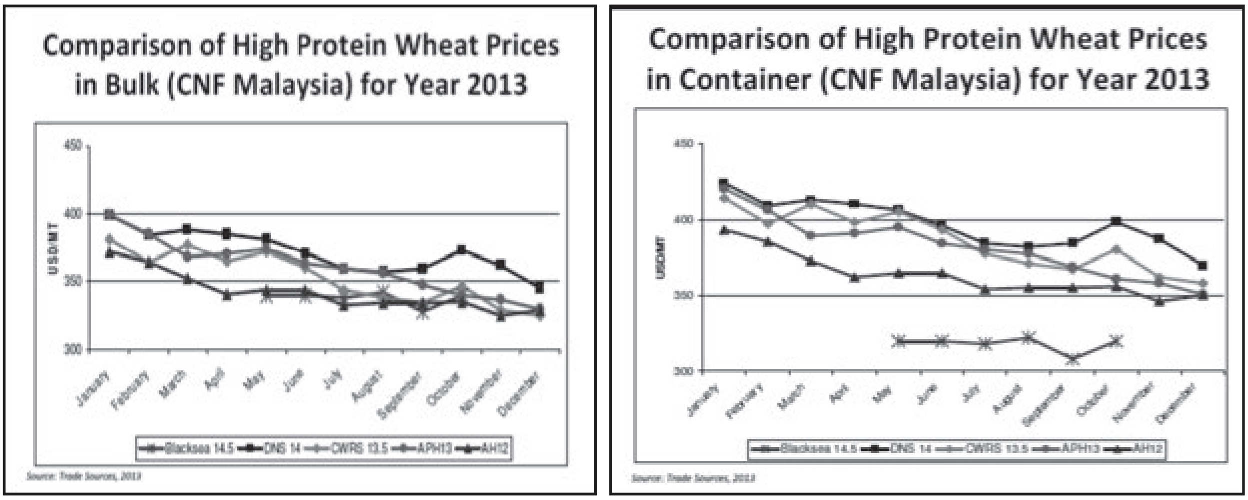


Figure 7. Comparison of high protein wheat prices into SE Asia – bulk vs container.

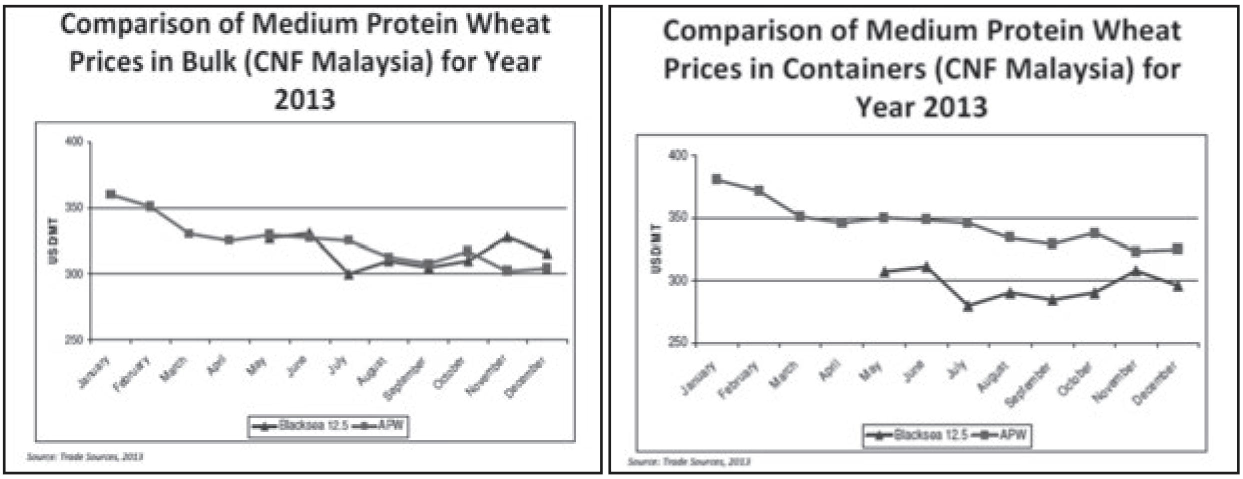


Figure 8. Comparison of medium protein wheat into SE Asia – bulk vs container.

1.1 Summary

Australian wheat is generally competitively priced into SE Asia and usually performs well in Asian food products with the exception of sponge and dough bread making. However, the quality of Australian wheat particularly in containerised shipments has declined post deregulation of the single desk. The amount of admixture has increased and there are large variations in quality from shipment to shipment. The maintenance of varietal integrity is sometimes not practised, for example, AH varieties are being passed off as APH. This is partly due to the lack of a centralised export quality inspection system like the FGIS in the USA and the Grain Commission in Canada.

Production of Black Sea wheat is increasing and the quality seems to be improving. Once they have fulfilled the market requirements of the Middle East and North Africa, SE Asia will become their next export target.

2. Competitive quality advantages of Australian wheat in Asian food products

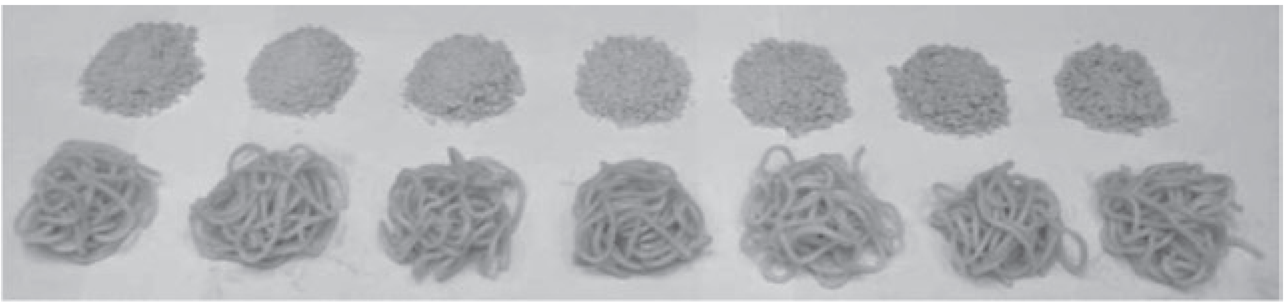
In Asia, wheat is mainly use for making noodles, bread, biscuits and streamed bread. These wheat based products are the staple food of many Asian countries and the consumption is growing rapidly with increasing disposable income in the region. Australian wheat is good quality white wheat and has many functional advantages in Asian foods, especially in noodle applications where it is important for the product to appear bright.

In recent years, Black Sea wheat has become more predominant and its quality has improved. The lower protein Black Sea wheat, with 11.5 to 12.5 per cent protein dry basis, performs well in biscuits and general purpose food applications. In bread making, Canadian and US spring wheat perform better than APH and AH wheat due to the predominance of the sponge and dough method of bread making in the region.

Asian food products have specific and unique wheat quality requirements for good end-product performance. We have studied the performance of different wheat types from different origins in Asian food products and our findings are as follows.

2.1 Flour quality requirements for noodles

- Bright yellow colour;
- Good gluten quality with high viscosity to produce firm and elastic noodle;
- Fast gluten development and good extensibility for easy sheeting and processing;
- Good colour stability for fresh noodle or wanton noodle; and
- High falling number with low enzyme activity for non-sticky noodles and longer shelf life (fresh noodles).



ASW APW10.5 HRW CPSW CPSR Russian Ukraine

Figure 9. Performance of different medium protein wheat types in alkaline noodle.

Summary of wheat performances in alkaline noodle.

- Water absorption: APW=HRW=CPSW>ASW=CPRS>Russian=Ukraine
- Brightness of colour: APW=CPSW> ASW>Russian > CPSR>HRW>Ukraine
- Texture/Strength: APW=HRW=CPSW>CPSR=Russian=Ukraine>ASW

Performance rating: APW =CPSW> HRW>CPSR=ASW>Ukraine = Russian wheat

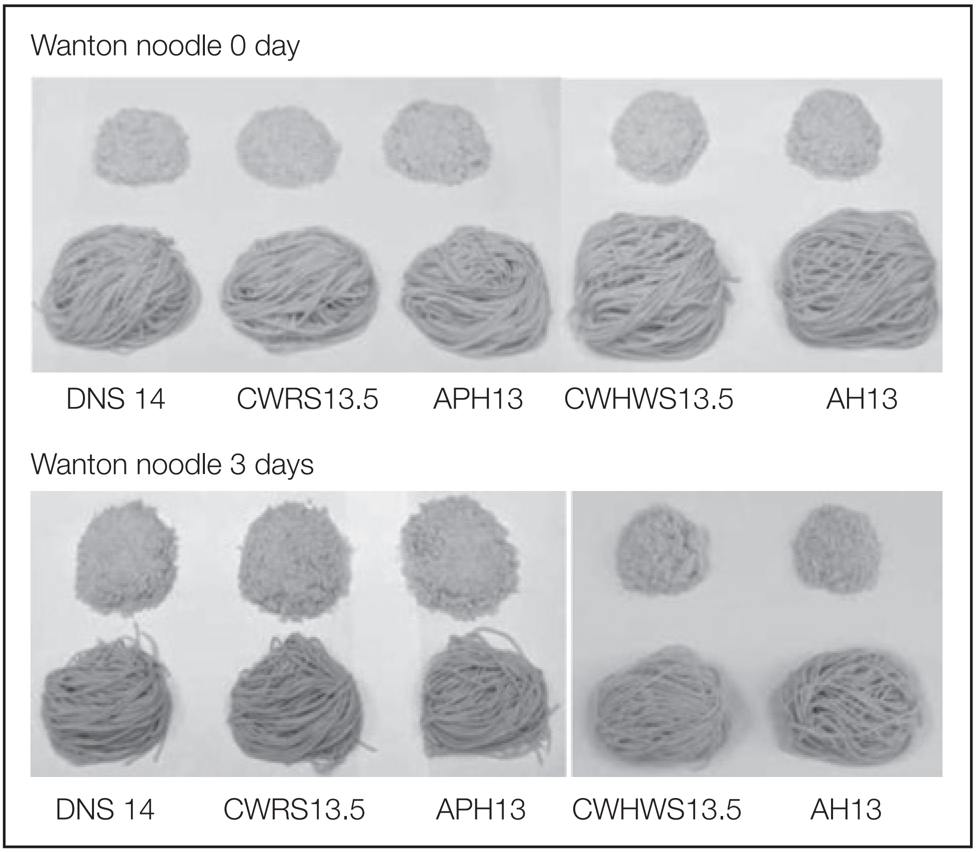


Figure 10. Colour stability of different wheat in wanton noodle.

Color stability rating: CWHWS>AH>APH>CWRS>DNS

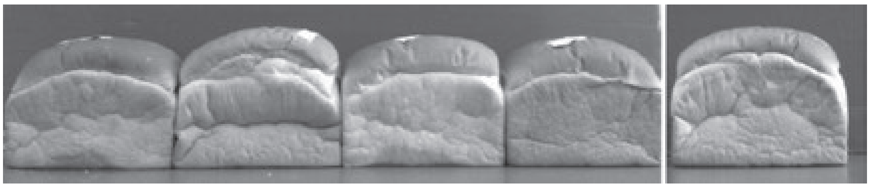
Table 1. Overall performance of wheat types in noodles

Wheat types	Origins	Quality rating	
		Good	Acceptable
APH/AH	Australia	V	
APW	Australia	V	
ASW	Australia		V
Indian Wheat	India		V
Pakistan wheat	Pakistan		V
Russian wheat	Russia		V
Ukraine wheat	Ukraine		V
HRW	USA		V
CWHWS/ CPSW	Canadian	V	

2.2 Flour quality requirements for breads

- High water absorption for better processing and high yield;
- Good gluten quality for better oven spring;
- Short mixing time with good mixing tolerance;
- Good gas retention to give good volume; and
- Soft eating quality for longer shelf life.

25% 37% 27% 27% 32% Oven spring



Russian14(DB) DNS14 AH12 KAZ13.5(DB) CWRS13.5

Figure 11. Performance of different wheat types in white bread.

Russian14(DB) DNS14 AH12 KAZ13.5(DB) CWRS13.5

Figure 12. Crumb structure.

Summary of wheat performances in bread.

- Water absorption: CWRS > DNS > KAZ > AH12 = Russian
- Oven spring: DNS > CWRS > AH12=KAZ > Russian
- Crumbs structure: DNS> CWRS=KAZ>AH12>Russian

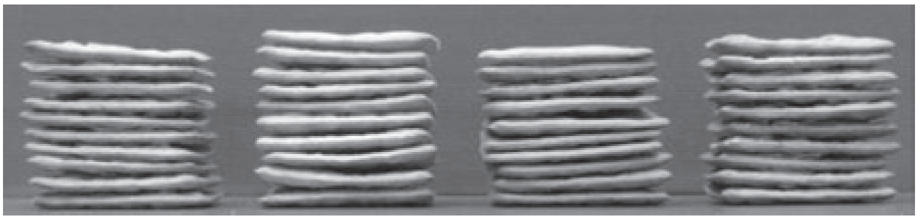
Performance rating: DNS > CWRS> KAZ=AH12> Russian wheat

Table 2. Overall performance of wheat types in bread

Wheat types	Origins	Quality rating	
		Good	Acceptable
APH13	Australia		V
AH12-13	Australia		V
CWRS13.5-14.5	Canadian	V	
CWHWS 13-14	Canadian		V
DNS14-15	USA	V	
HRW13	USA		V
High protein Black Sea wheat 14.5 -15% (db)	Kazkhastan Lithuanian Russian Ukraine		V V V V

2.3 Flour quality requirements for biscuits

- Extensible dough characteristic for better sheeting process;
- Strong gluten quality for good fermentation tolerance (cracker production);
- Fast hydration rate and short mixing time; and
- Produce light, flaky and crispy biscuits.



APH13 CWRS13.5 CWHWS 13 DNS14

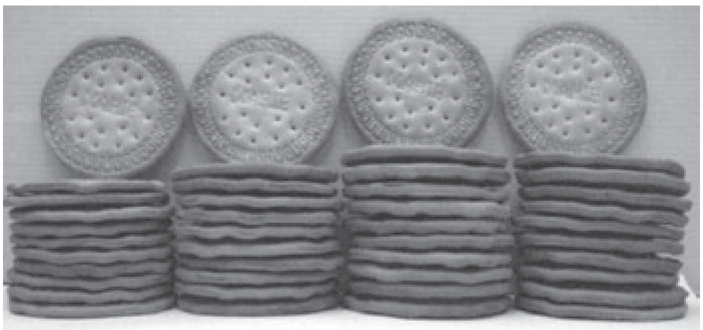
Figure 13. Performance of different wheat types in cream cracker.

Summary of wheat performances in cream cracker.

- CWRS13.5 and DNS14 showed better puffiness than APH13 and CWHWS; and
- CWHWS and CWRS13.5 provide better eating quality; the biscuit is more flaky and crispy.

Performance rating: CWRS13.5 > CWHWS = APH > DNS

120% 125% 140% 133% Leavening effect



APW ASW UKRAINE 11.5 (DB) RUSSIAN 11.5(DB)

Figure 14. Performance of different wheat types in marie biscuit.

Summary of wheat performances in marie biscuit.

- Ukraine and Russian wheat can give a better puffiness, crispy and loose texture marie biscuits than ASW and APW wheat.

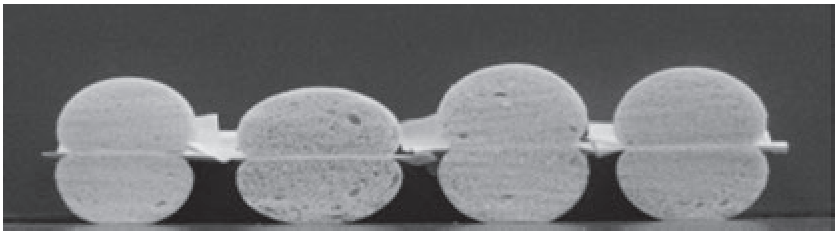
Quality rating: Ukraine > Russian> ASW> APW

Table 3. Overall performance of wheat types in marie biscuit flour

Wheat types	Origins	Quality rating	
		Good	Acceptable
APW	Australia		V
CPSR	Canadian		V
ASW	Australia	V	
Indian wheat	India		V
Russian wheat	Russian	V	
Ukraine wheat	Ukraine	V	

2.4 Flour quality requirements for steamed bread

- Bright and white color;
- Good symmetry form/shape;
- Good water absorption for easy processing; and
- Soft and springy eating quality.



APW Indian wheat Ukraine 12.5 (DB) Russian 12.5 (DB)

Figure 15. Performance of different wheat types in steamed bread.

Summary of wheat performances in streamed bread.

- APW showed a brighter/whiter color and good shape;
- Russian and Ukraine wheat gave good volume, but the color is not as good as APW; and
- Indian wheat is not suitable to use in steamed bread.

Performance rating: APW > Russian=Ukraine> Indian wheat

Table 4. Overall performance of wheat types in steamed bread

Wheat types	Origins	Quality rating	
		Good	Acceptable
APW	Australia	V	
Indian wheat	India		No
Ukraine wheat	Ukraine		V
Russian wheat	Russia		V

3. Comparison of new prime hard varieties (EGA Kidman and Gascoigne blend) developed for sponge and dough bread making against DNS14 and CWRS13.5

3.1 Open top white bread using sponge and dough method Sponge surface.

Smooth surface | Smooth surface | Rough surface with gas bubbles

100% DNS14 | 100% CWRS13.5 | 00% 1 APH13

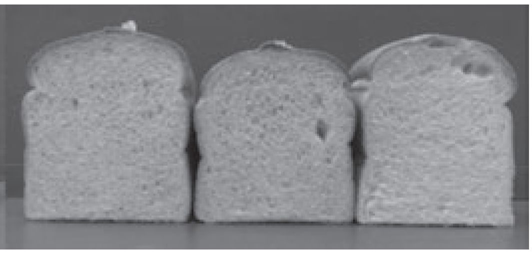
Figure16. Sponge characteristic after 4 hours fermentation.

25% | 20% | 22%

100% DNS | 100% CWRS | 100% APH

Figure 17. Oven spring.

Fine | Slightly fine | Bright and fine



100% DNS | 100% CWRS | 100% APH

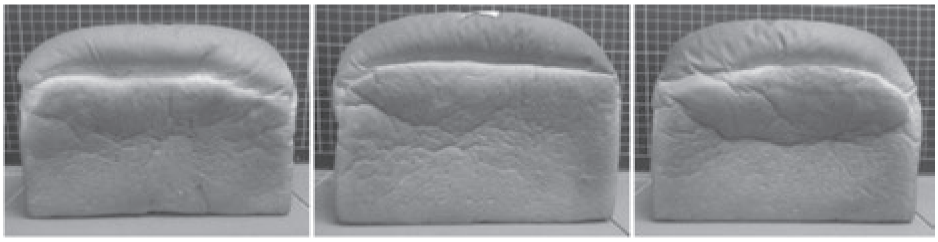
Figure 18. Crumb structure.

Findings.

- 100% DNS gave the best quality bread because of good sponge tolerance, oven spring and crumb structure;
- 100% APH13 showed poor sponge tolerance, however the oven spring and crumb structure are good and acceptable; and
- 100% CWRS gave good sponge tolerance but the bread performance is the poorest among all wheat.

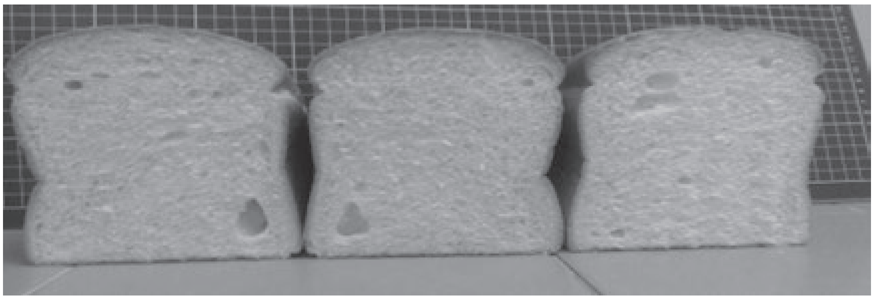
3.2 Combination of APH with North American spring wheat

20% 20% 20% Oven spring



50% DNS / 50% CWRS — 50% DNS / 50% APH — 50% CWRS / 50% APH13

Figure 19. Oven spring.



50% DNS / 50% CWRS — 50% DNS / 50% APH — 50% CWRS / 50% APH13

Figure 20. Crumb structure.

Findings.

All samples showed insignificant difference for oven spring and crumb structure. From the results, we found APH (Kidman & Gascoigne blend) is able to perform reasonably well in sponge and dough bread making. However its sponge tolerence is weaker when compared to North American spring wheats. Nevertheless, these new APH varieties can be used in conjunction with North American spring wheat for bread making with good results .

3.3 Summary

The stronger North American spring wheats perform better than Australian APH and AH wheat in bread products. There is potential for lower protein Black Sea wheat to replace ASW/APW and high protein Black Sea wheat to replace APH/AH wheat in many Asian food products .

The search for a white wheat that will perform well in both noodles and bread making rages on both sides of the Pacific Ocean. The lastest prime hard varieties of EGA Kidman and Gascoigne seem to offer promise. The CWHWS from North American gives a reasonable performance in bread, noodles and biscuits applications and therefore has the potential to be a universal white wheat.

4. Competitive position of Australian canola to SE Asia

Canola is now a major crop in Australia. In general, the quality of Australian canola is as good as, or better than, Canadian or Black Sea canola. The oil content is usually higher and the glucosinolate content is lower.

Favourable freight spreads makes Australian canola competitive into SE Asia, but due to the fact that there are only a few crushers crushing canola in SE Asia most of the canola is exported to Europe and the Indian subcontinent. However, the increasing demand for canola oil in SE Asia, and the fact that canola meal is beginning to gain acceptance as an alternative protein source to soybean meal in poultry, will encourage crushers in the region to start crushing canola.

Recently, large canola crops in the Black Sea region resulted in cheap canola exports, but only for a short period of time after their harvest. We find Black Sea canola usually has a lower oil content and higher glucosinolate levels.

Although canola oil is viewed as a premium cooking oil in the region, canola meal is not perceived as an equal alternative to soybean meal in poultry despite the higher levels of methionine. This is due to the lower protein levels and higher fibre content of canola meal when compared with dehulled soybean meal which is the gold standard for protein supplementation of poultry feed . The processing of canola meal causes more damage to the protein and energy contents when compared to soybean meal processing. Furthermore, dehulling of canola meal is not commercially viable. However, improvements in canola processing, developed by our company, have produced a canola meal that performs better than other canola meals and is similar to the soybean meal control diet in scientifically controlled feeding trials with broilers. Cold pressed canola meal was also tested to have higher energy and amino acid availability than regular canola meal.

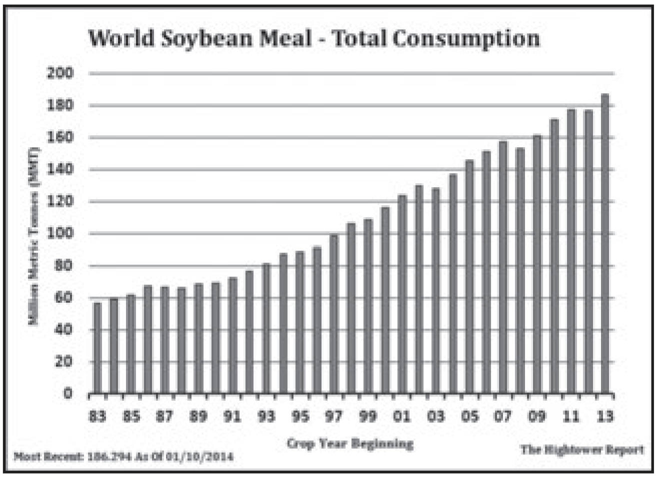


Figure 21. World consumption for soybean meal.

A broiler trial was conducted at Bangkok Animal Research Centre in Thailand comparing the growth performance of broiler chicks fed with solvent extracted canola meal from various origins using a corn soy diet as control.

A total of three hundred and twelve newly hatched male broiler chicks of commercial strain (Ross 308) were randomly allocated to four treatments with six replications using 13 chicks in a pen as an experimental unit. Feeds were prepared for two phases of feeding. Starter feeds were offered from day one until day 16, whereas grower feeds were fed from day 17 until day 34. Solvent extracted canola meal was included at 5 per cent in the starter diet and 10 per cent in the grower diet. Feed and water were offered ad libitum through out the whole experiment. Body weight gain (BWG), feed conversion rate (FCR), feed Intake, livability rate and fecal score were recorded and measured in this trial. Table 5 demonstrates overall growth performance results for the 34 days of feeding.

The above results show that broilers fed with the diet containing Soon Soon canola meal performed significantly ($p<0.05$) better in feed conversion than those fed with diets containing Australian or Dubai canola meals and the results were similar to the control diet. There were no significant difference in BWG, feed intake, livability and fecal score among

Table 5. Growth performance (34 days) of broilers fed with diets containing canola meals of different origins compared with a corn soy control diet

Treatments	Initial BW (g)	Final BW (g)	BWG (g)	Feed intake (g)	FCR[1]	Livability (%)	Fecal scoring[2] (at 34 d)
Control	43	2664	2622	3597	1.372 [b]	98.7	2.75
Soon Soon	43	2616	2574	3534	1.373 [b]	100	2.25
Australia	43	2599	2556	3572	1.397 [a]	100	2.33
Dubai	43	2608	2566	3573	1.393 [a]	98.7	2.25
P-Value		*0.1393*	*0.1383*	*0.5432*	*0.0135*	*0.6098*	*0.2377*
Pooled SEM		*19.894*	*19.849*	*30.367*	*0.006*	*0.936*	*0.191*
C.V., %		*1.86*	*1.89*	*2.08*	*1.06*	*2.31*	*19.52*

[a,b,c] *Means within column with no common superscript differ significantly (p<0.05).*

[1] *Feed conversion rate corrected for mortality and culls.*

[2] *Fecal scoring was measured by scoring 1-5; where 1 = hard dry pellet, 2 = firm formed stool (not too dry), 3 = soft moist stool that retains shape, 4 = soft unformed stool that assumes shape of container (it has more moisture), 5 = watery liquid that can be poured.*

all the diets. The results indicate that Soon Soon canola meal has more nutrient availability probably as a result of better processing when compared to Australian and Dubai canola meals.

5. Potential of Australian soybeans in Asian food markets

The SE Asian region accounts for 25 per cent of the world's soy food consumption. Annually 3.5 million tonnes of food soybeans are used to produce tempe, tofu, soy milk etc. The main suppliers are Canada and USA. Australia has the potential to supply the top end of this market. Our own evaluation has shows that certain varieties of Australian soybeans can perform well in soy milk and tofu.

We evaluated the performance of Australian soybean against Canadian and US soybean in soy milk and tofu. Our conclusion is that Australian soybean can perform well in both products.

Table 6. South East Asia food soybean utilization 2011

Product Category	GM beans	Non GM beans	Total
Tempe	1,840,000	-	1,840,000
Tofu	700,000	40,000	740,000
Soy milk	500,000	80,000	580,000
Other soy products(soysauce)	200,000	-	200,000
Bakery, processed meat, TSP	-	10,000	10,000
TOTAL	3,240,000	130,000	3,370,000

Source: USDA and government data.

Table 7. Comparison between Australian, Canadian and USA soybeans

	Australian non GM	Canadian GM	Canadian IP non GM	USA GMO
Moisture, %	10.8	12.9	11.7	11.5
Protein (dry basis),%	40.5	41.1	42.1	40.3
Oil, %	19.1	19.1	20.0	19.9
Water uptake factor	2.16	2.10	2.12	2.1
Soy milk yield, g	2890	2820	2892	2780
Tofu yield, g	868.9	874.2	870.5	844.8

Australian Non GM   Canadian GM   Canadian IP non GM   US GM

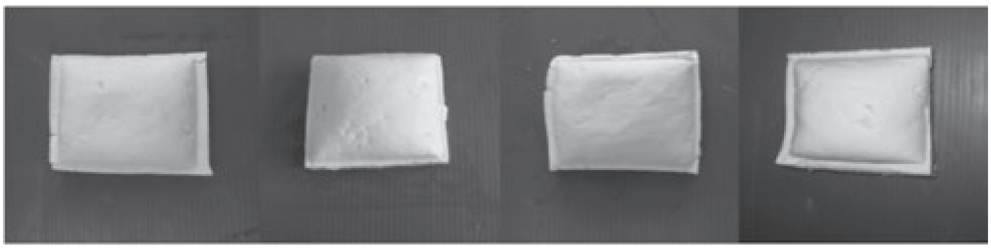
Figure 22. Soybeans from different origins.

Australian Non GM   Canadian GM   Canadian IP non GM   US GM

Figure 23. Soy milk produced from different type of soybeans.

5.1. Findings

Soy milk made from Australian non-GM soybean was more yellowish than the soybean milk from Canadian and USA soybeans. The taste is considered better than the US GM soybean milk but is not as good as Canadian identity preserved (IP) non-GM soybean milk.



Australian Non GM   Canadian GM   Canadian IP non GM   US GM

Figure 24. Tofu produces from different types of soybean.

- Tofu made from all the soybeans were soft and smooth and were similar in quality;
- Tofu made from Canadian GM soybean has the highest yield (874g), followed by Canadian IP non-GM (870.5g), Australian non-GM and US GM soybean (844.8g); and
- Overall, Canadian soybean perform the best in soy milk and tofu, followed by Australian soybean and lastly US soybean.

Overall traits of a good quality food soybean:

- High protein;
- Size – large seed and uniform size;
- Hilum – clear and yellow cotyledon;
- Seed coat – thin and yellow;
- Soluble sugars – high soluble sugars for natural sweet taste; and
- Protein quality 11s:7s ratio.

6. Opportunities for the use of lupins in Asian foods and animal feeds

Recent initiatives by the WHO to reduce NCDs such as cardiovascular diseases, cancer, diabetes and chronic respiration disease by 25 per cent by 2025 has opened new opportunities to use lupin in Asian processed foods such as noodles, sausages, bread, biscuits etc.

Lupin flour has been proven in numerous researches to reduce post prandrial blood sugar levels when incorporated in bread. There are also evidences that it helps in the prevention of cardiovascular diseases. Our own research shows that lupin can be successfully incorporated into Asian food products with little change in taste and functionality.

6.1. World Health Organisation global noncommunicable diseases action plan 2013-2020 targets

Voluntary global targets.

1) A 25 per cent relative reduction in the overall mortality from cardiovascular diseases, cancer, diabetes, or chronic respiratory diseases;
2) At least 10 per cent relative reduction in the harmful use of alcohol, as appropriate, within the national context;
3) A 10 per cent relative reduction in prevalence of insufficient physical activity;
4) A 30 per cent relative reduction in mean population intake of salt/sodium;
5) A 30 per cent relative reduction in prevalence of current tobacco use in persons aged 15+ years;
6) A 25 per cent relative reduction in the prevalence of raised blood pressure or contain the prevalence of raised blood pressure, according to national circumstances;
7) Halt the rise in diabetes and obesity;
8) At least 50 per cent of eligible people receive drug therapy and counselling, including glycaemic control, to prevent heart attacks and strokes;
9) An 80 per cent availability of the affordable basic technologies and essential medicines, including generics, required to treat major noncommunicable diseases in both public and private facilities.

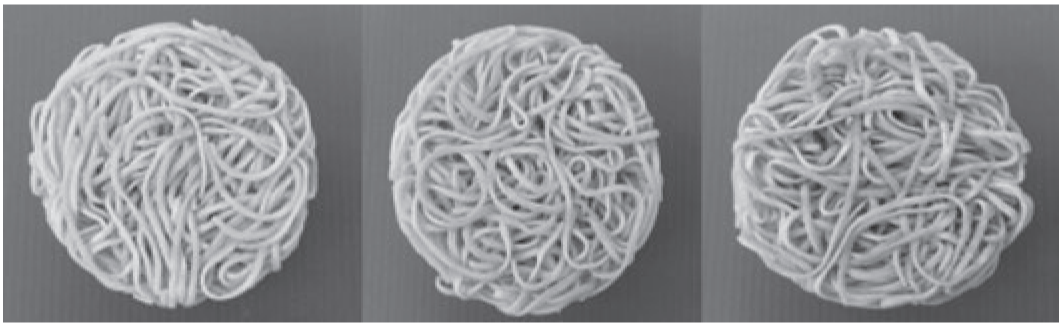
6.2. Use of Lupin flour and fibre in instant noodles

Findings.

Instant noodles incorporating lupin flour and lupin fibre showed increased protein and dietary fibre content. The noodle appearance is more yellow when compare to control.

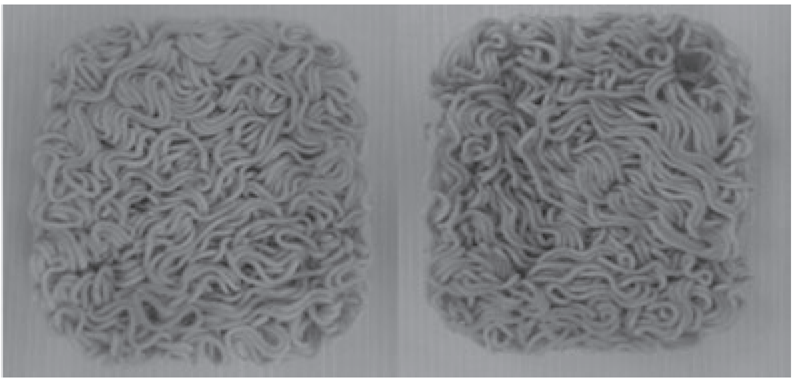
Table 8. Analysis of instant noodles incorporating lupin flour and fibre

	Laboratory Instant noodle samples			Commercial samples	
	Control	Sample with 6.8% Lupin flour	Sample with 6.7% lupin flour and 1.7% Lupin fibre	Control	Sample with 6.8% lupin flour
Moisture, %	3.8	4.2	4.1	2.5	2.4
Protein (dry basis), %	10.3	12.5	12.1	11.1	12.7
Dietary Fibre (dry basis) , %	4.3	7.1	8.8	3.6	6.4
Oil (dry basis), %	18.5	17.8	17.9	13.6	15.5



Control 6.8% Lupin flour Incorporating 6.7% lupin flour and 1.6% Lupin fibre

Figure 25. Laboratory test instant noodles sample.



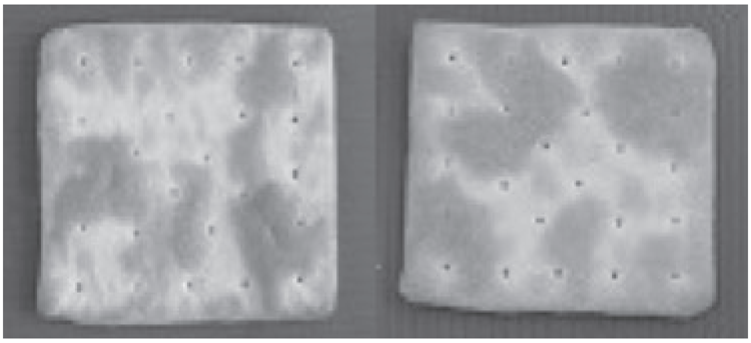
Control Incorporating 6.8% lupin flour

Figure 26. Commercial instant noodles using lupin flour.

6.3. Use of lupin flour and lupin fibre in cracker

Table 9. Analysis of cracker incorporating lupin flour and libre

	Control	Sample with 5.8% lupin flour and 1.5% lupin fibre
Moisture, %	2.8	3.1
Protein (dry basis), %	12.3	12.7
Dietary fibre (dry basis), %	3.1	7.0



Control — Incorporating 5.8% Lupin flour and 1.5% Lupin fibre

Figure 27. Laboratory test cracker samples.

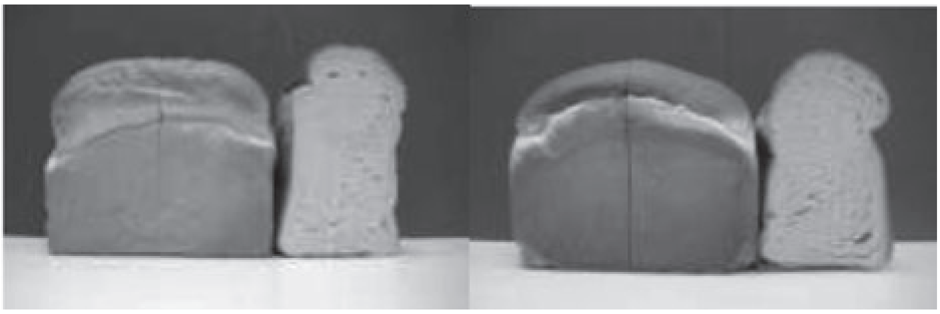
Findings.

Cracker incorporating lupin flour and lupin fibre showed increased protein and dietary fibre content without significant changes in taste profile.

6.4. Use of lupin flour and lupin fibre in bread

Table 10: Analysis of breads incorporating lupin flour

	Control	Sample with 7% Lupin flour
Protein content, as is (%)	11.2	16.7
Dietary fibre, as is (%)	1.73	4.45



Control — Incorporating 7% lupin flour

Figure 28. Laboratory test bread samples.

The benefits of adding Lupin flour in bread.

- Dietary fibre increased by 157 per cent;
- Protein increased by 49 per cent; and
- The bread can label as ‘good source of fibre’ because it contains 4.5 per cent of dietary fibre.

6.5. Summary

Sweetingham et al. has shown lupin can replace soybean in soy foods such as soy milk, tofu, tempe, miso etc. Our own research shows that lupin flour can increase the protein and dietary fibre content of instant noodle, cracker and bread. Supplementation of lupin flour and fibre can be recommended for producing healthier Asian food products.

In recent years, almost all soybeans grown in the USA and Argentine are genetically modified (GMO). There is much consumer resistance to GMO foods. Lupins are non-GMO and therefore it can be a cost effective non-GMO replacer for soybean.

6.6. Use of lupin in animal feedings

Lupin can be used as a protein source for animal feeding. Research done in Australia has shown that dehulled lupin meal can be a better protein source than soybean meal in aquaculture. Our own research shows that when properly processed, dehulled lupin meal can also be as good as or better than soybean meal in poultry and pig feeding.

Broiler trial.

Recently, we developed a new high fat product from lupin seed using a special processing method. This product is dehulled and co-processed with soy-lecithin to pre-emulsify its oil for enhancing its availability to animals, especially young animals like piglets and broiler chicks. This product has a total ether extract of around 16 per cent and protein content of 36 per cent. Its estimated nutrient matrixes are demonstrated in Table 11. This product can be used as protein and energy sources in animal feedings.

A broiler trial was conducted to investigate the effects of incorporating 5 to 15 per cent of this dehulled pre-emulsified full fat lupin meal in broiler diets using soybean meal as control. The trial was carried out at Bangkok Animal Research Centre in Thailand for a period of 34 days. A total of 384 day old male Arbor Acres Plus broiler chicks were used in this study. Chicks were assigned to four treatments with six replicates per treatment. The chicks were allocated equally over 24 pens at 16 chicks per pen. Four treatments diets were prepared with 0 per cent, 5 per cent, 10 per cent and 15 per cent of canola meal in both starter and grower diets. Starter diets were fed from day zero to day 16 and grower diets were fed from day 17 to day 34. At the end 34 days, body weight gain (BWG), feed intake (FI), feed conversion ratio (FCR), livability and fecal scores were calculated. The overall growth performances for 34 days of feedings are shown in Table 12.

Table 11. Estimated nutrient matrixes for dehulled pre-emulsified full fat lupin meal

Item	FF Lupin meal
Crude Protein, g/kg	360
ME Poultry, MJ/kg	13.6
Crude Fat, g/kg	160
Crude Fibre, g/kg	38
Digestible Lysine, g/kg	16.12
Digestible Methionine, g/kg	2.51
Digestible M+C, g/kg	8.16
Digestible Tryptophan, g/kg	2.29
Digestible Threonine, g/kg	12.54
Digestible Arginine, g/kg	38.39
Digestible Isoleucine, g/kg	16.06
Digestible Valine, g/kg	14.63

Table 12. Growth performances of broilers fed with various inclusion rates of dehulled pre-emulsified full fat lupin meal for 0 to 34 days

Treatment diets	Initial BW (g)	Final BW (g)	BWG (g)	FI (g)	FCR[1]	Livability (%)	Fecal score*
Control	44	2605	2561	3895 [ab]	1.521	97.9	2.17
5% FF Lupin meal	44	2578	2534	3845 [b]	1.518	96.9	2.17
10% FF Lupin meal	44	2657	2613	3976 [a]	1.522	95.9	2.33
15% FF Lupin meal	44	2593	2548	3832 [b]	1.504	100.0	2.17
P-value		*0.2024*	*0.202*	*0.0221*	*0.3351*	*0.2113*	-
Pooled SEM		*26.24*	*26.266*	*31.513*	*0.008*	*1.36*	-
C.V.%		*2.46*	*2.51*	*1.99*	*1.24*	*3.41*	-

[a,b] Means within column with no common superscript differ significantly (P<0.05).

[1] Feed conversion ratio corrected for mortality and culls.

**Fecal score: 1= Hard, 2= Soft, 3= Watery.*

The results showed that there are no significant differences (p > 0.2) in BWG, FCR and livability for broilers fed the lupin meal diets at 5 per cent, 10 per cent and 15 per cent inclusion rates when compared to the control diet using soybean meal. Broilers fed with the 10 per cent lupin meal diet had the highest feed intake, which is significant higher than the 5 per cent and 15 per cent lupin meal diets, but there was no significant difference when compared to the control diet.

Numerically, the birds fed 10 per cent lupin meal had the highest body weight gain among all the diets. All treatment diets shown good livability (≥ 95%) and normal fecel scores. This demonstrated that dehulled pre-emulsified full fat lupin meal can be used at inclusion rate of up to 15 per cent in the broiler diets without any negative growth effects. High levels of lupin meal in the broiler diet are often restricted to avoid problems associated with excess moisture in the excreta (Robert J. van Barneveld, 1999). Most commercial broiler farms and feed mills in Australia use less than 10 per cent inclusion level in poultry diets. However, when using this dehulled pre-emulsified full fat lupin meal at 15 per cent in the diet there was no abnormal fecel conditions when compare to the control diet.

Pig trial.

Lupins can be used at higher level in pig diets without affecting feed intake and growth performances. Edwards and van Bernaveld (1998) reported a maximum recommended inclusion rate of L. angusfolius in pig diets to be 100 to 150 g/kg for weaner (up to 20 kg liveweight), 200 to 250 g/kg for grower (20 to 50 kg liveweight), and 300 to 350 g/kg for finisher (up to 100 kg liveweight).

The limitations of lupin meal are due to comparative deficiency of lysine, methionine and cysteine, Table 13 (Peterson 2000). When properly processed to maximise nutrient availability, lupin meal can be used to partially replace soybean meal in pig feeding. An experiment was carried out in a commercial pig farm in Malaysia to investigate the performance of grower pigs when fed a diet replacing 75 per cent of soybean meal with lupin meal. The experiment was conducted for a period 56 days. A total of 60 cross-bred grower pigs (Landrace x Large White x Duroc) were used in this study. They were penned in 20 pens with 3 pigs in each pen. The pigs were reared according to the normal farm practices.

Table 13. Amino acids composition (g amino acid/16 g N) of lupin and soybean meal

Amino acids	L. angufolius	Soybean meal
Lysine	4.66	5.66
Methionine	0.72	1.28
Tryptophan	1.00	1.35
Arginine	11.62	5.42
Threonine	3.54	3.56

Table 14 shows the growth performances of grower pigs fed with soybean meal and lupin meal diets. The pigs fed the lupin meal diet had a lower ($P<0.05$) feed intake and better ($P<0.05$) feed conversion than those fed with the soybean meal diet. These results show that the pigs are able to utilise the feed more efficiently in the lupin meal diet compared to the soybean meal diet.

7. Conclusion and recommendations

Australian wheat is price competitive into SE Asia and usually performs well in Asian food products with the exception of sponge and dough bread making where North American spring wheat predominates. New varieties of APH such as Kidman and Gascoigne performed well in sponge and dough bread making but not better than North American spring wheat.

Increased production of Black Sea wheat is increasing its price competitiveness in SE Asia, where the lower protein varieties can replace APW/ASW and the higher protein varieties can replace AH in many Asian food products. With increasing export surpluses, Black Sea wheat has the potential to be a major competitor for Australian wheat in SE Asia.

Post deregulation has increased the sales of Australian wheat to SE Asia at the expense of the Middle East due to freight spreads favouring SE Asia. Container shipments have reached about 2 million tonnes per annum and the numbers of customers of Australian wheat have also increased significantly. However, the quality of Australian wheat, particularly in containerised shipments, has deteriorated with higher levels of admixture, large variations in quality from shipment to shipment and many shippers do not respect varietal integrity. Much of these problems are due to the lack of proper export quality inspection for containerised shipments.

In order to maintain the reputation of Australian wheat and its competitiveness, we recommend that a centralised export quality inspection service like the FGIS in USA and the Grain commission in

Table 14. Effects of replacing soybean meal with lupin meal on the growth performances of growing pigs for a period of eight weeks

Treatments	Soybean meal diet	Lupin meal diet
Growth performance		
Initial body weight (kg)	21.93±0.73[a]	22.21±0.63[a]
Average feed intake (kg/day/pig)	1.59±0.06[a]	1.36±0.05[b]
Total live weight gain, g/day/pig	571.43±16.18[a]	563.90±17.15[a]
Final body weight (kg)	53.93±1.71[a]	53.42±1.47[a]
Feed conversion ratio	2.79±0.10[a]	2.41±0.09[b]

Note. Results are presented as mean ± standard deviation. Values with different superscripts within rows differ significantly from each other at 95 per cent.

Canada be set-up to inspect all Australian grain exports.

Another problem after deregulation is the lack of a centralised annual crop report. Buyers do not really know the quality of wheat in various regions of Australia. Therefore the reestablishment of an annual centralised crop report will help to promote Australian wheat. Finally it would be useful if there is a centralised research facility for customers to test Australian grains and oilseeds in their products and also allow Australian scientist to develop new varieties of wheat, soybeans and other grains to suit export customer requirements.

Other Australian grains and oilseeds such as lupin, soybeans and canola are potentially competitive in SE Asia. One quarter of the world's soy food is produced in SE Asia. Our research has shown that certain Australian soybean varieties can perform well for soymilk and tofu. The recent announcement by the WHO of a programme to reduce NCDs by 25 per cent can encourage the use of lupins and soybeans in Asian food products as nutracetical supplements potentially capable of reducing the incidences of diabetes and cardiovascular diseases as well as increasing fibre and protein in foods.

Dehulled Lupins can also be use effectively as a protein supplement to replace imported soybean meal in poultry and swine feeding. With increasing canola oil and meal use in the region, Asian oilseed crushers are starting to crush canola. Australian canola is competitive but recent large Black Sea canola crop has resulted in low export prices from the region to SE Asia.

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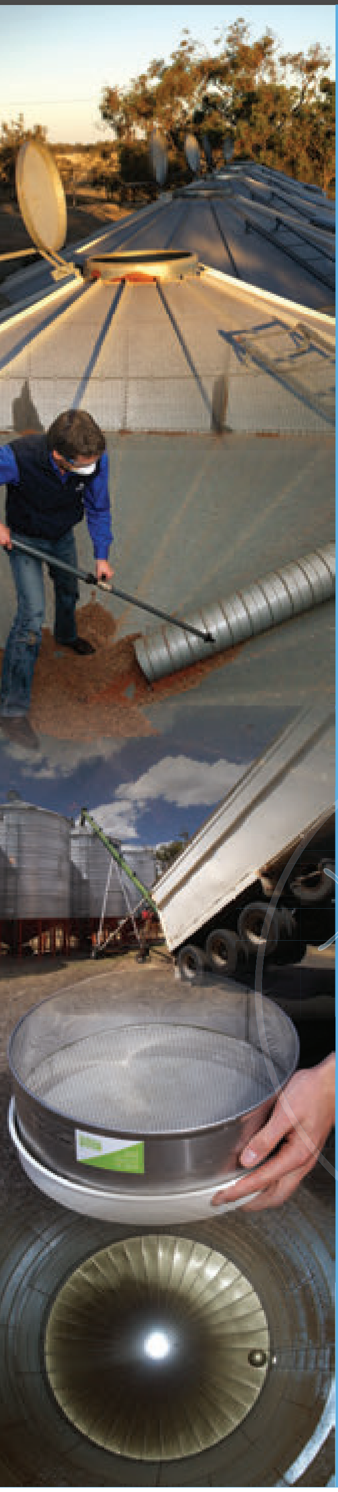

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*** Networking time - refreshments - AGT**

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Wednesday 26th February – Day 2

CONCURRENT SESSIONS

(40 minutes including time for room change) (R = session to be repeated)

	Main Hall	Rooms 1-2	Rooms 10-11	Rooms 4-5
9.00am	**Barley varieties - 2014 best and fairest (R)** - P191 ***Jason Eglinton,*** *University of Adelaide*	**New aspects on potassium nutrition (R)** - P199 ***Rob Norton,*** *IPNI*	**Spots, blots and rots - cereal disease update (R)** - P205 ***Hugh Wallwork,*** *SARDI and* ***Marg Evans,*** *SARDI*	**Wheat variety review (R)** - P209 ***Rob Wheeler,*** *SARDI*
9.40am	**Managing stacked resistance in wild radish (R)** - P217 ***Grant Thompson,*** *Crop Circle Consulting*	**Barley varieties - 2014 best and fairest** - P191 ***Jason Eglinton,*** *University of Adelaide*	**New aspects on potassium nutrition** - P199 ***Rob Norton,*** *IPNI*	**Spots, blots and rots - cereal disease update** - P205 ***Hugh Wallwork,*** *SARDI and* ***Marg Evans,*** *SARDI*
10.20pm	***Morning tea***			
10.50am	**Wheat variety review** - P209 ***Rob Wheeler,*** *SARDI*	**Managing stacked resistance in wild radish** - P217 ***Grant Thompson,*** *Crop Circle Consulting*	**Soil moisture probes and Yield Prophet®- how do they assist real decision making? (R)** - P229 ***Harm van Rees,*** *Cropfacts*	**Bio pesticides - fresh hope for future options (R)** - P237 ***Gavin Ash,*** *Charles Sturt University*

CONCURRENT SESSIONS

(40 minutes including time for room change) *(R = session to be repeated)*

	Main Hall	Rooms 1-2	Rooms 10-11	Rooms 4-5
11.30am	**Opportunities with liquid systems (R)** - P241 & 245 ***Peter Burgess,*** *Liquid Systems and* ***Alan McKay,*** *SARDI*	**Soil moisture probes and Yield Prophet®- how do they assist real decision making?** - P229 ***Harm van Rees,*** *Cropfacts*	**Improving seasonal forecasts** - P251 ***Darren Ray,*** *Bureau of Meteorology*	**Embracing opportunities and challenges with soil amelioration (R)** - P253 & 259 ***Dave Davenport,*** *SARDI and* ***Roger Groocock,*** *Groocock Soil Improvement*
12.10pm	**Embracing opportunities and challenges with soil amelioration** - P253 & 259 ***Dave Davenport,*** *SARDI and* ***Roger Groocock,*** *Groocock Soil Improvement*	**Opportunities with liquid systems** - P241 & 245 ***Peter Burgess,*** *Liquid Systems and* ***Alan McKay,*** *SARDI*	**Bio pesticides - fresh hope for future options** - P237 ***Gavin Ash,*** *Charles Sturt University*	**Snail control update** - P263 ***Greg Baker,*** *SARDI*

12.50pm ***Lunch***

1.40pm **Robotics and intelligent systems for broad acre agriculture** - P271 — ***Salah Sukkarieh,*** *University of Sydney*

2.20pm **Helping your clients build their emotional and personal resilience** - P275 — ***Dennis Hoiberg,*** *Lessons Learnt Consulting*

3.00pm **Close and evaluation**

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Barley variety update 2014

Jason Eglinton*[1] *and Rob Wheeler*[2]*,
[1] University of Adelaide, [2] SARDI, Waite

Keywords

barley, new variety performance, National Variety Trials, variety adoption

Take home messages

- **Compass$^{\phi}$ and La Trobe$^{\phi}$ lead NVT yield results.**
- **2013 results highlight varietal differences in grain size.**
- **Barley productivity in SA continues to increase.**

The 2013 Season

The area sown to barley in South Australia in 2013/14 is estimated at 925,000 hectares which is slightly above the current five year average, possibly influenced by limited early sowing opportunities in some districts. Barley production is estimated at 2.28 million tonnes for 2013/14 with a state wide average yield of 2.47 t/ha (ABARES 2013). The changes in barley yield in South Australia are illustrated in Figure 1 which shows the five year rolling mean since 1970. Grain yield doubled in the period from 1970 to 2000 but was significantly affected by drought conditions in 2007 and 2008 and the 'millennium drought' of 2006. The five year average has now recovered back up to the long term trend for productivity increases as shown in Figure 1, with the current five year average at 2.27 t/ha. The trends in variety adoption seen over the past few years continued in 2013, with Hindmarsh$^{\phi}$, Commander$^{\phi}$, Fleet$^{\phi}$ and Buloke$^{\phi}$ firmly established as the dominant varieties. The older varieties, Schooner$^{\phi}$, Barque, Gairdner$^{\phi}$, SloopSA$^{\phi}$, Maritime$^{\phi}$, Keel and Flagship$^{\phi}$ have now dropped to very low production levels. The area sown to Scope$^{\phi}$ significantly increased, however the seasonal conditions in 2013 exposed agronomic weaknesses in Scope$^{\phi}$ compared to the leading varieties. Production levels of Scope$^{\phi}$ in 2014 may be strongly influenced by summer rainfall and the risk of herbicide residues.

Barley prices have steadily increased since the start of harvest and the malt1 premium has been around \$40/t, although there has also been differential pricing of malting varieties of more than \$10/t. Premiums for Hindmarsh$^{\phi}$ have generally been around \$10/t above feed1 but there has been volatility with prices at times matching the best malt1 bids which underlines the solid international market demand for Hindmarsh$^{\phi}$ despite its 'Food Grade' quality status.

Season 2013/14 generally began with good conditions with rainfall to the end of July ranging from average to well above average. Winter temperatures were above average which accelerated crop development, producing thick heavy canopies with very high yield potential and lodging risk in early sown crops. The moisture and temperature profiles also favoured the development of the two forms of net blotch. The net form of net blotch was prevalent particularly in heavy crops and differences in the virulence of pathotypes continued to result in varieties exhibiting different levels of infection depending on the races of the pathogen

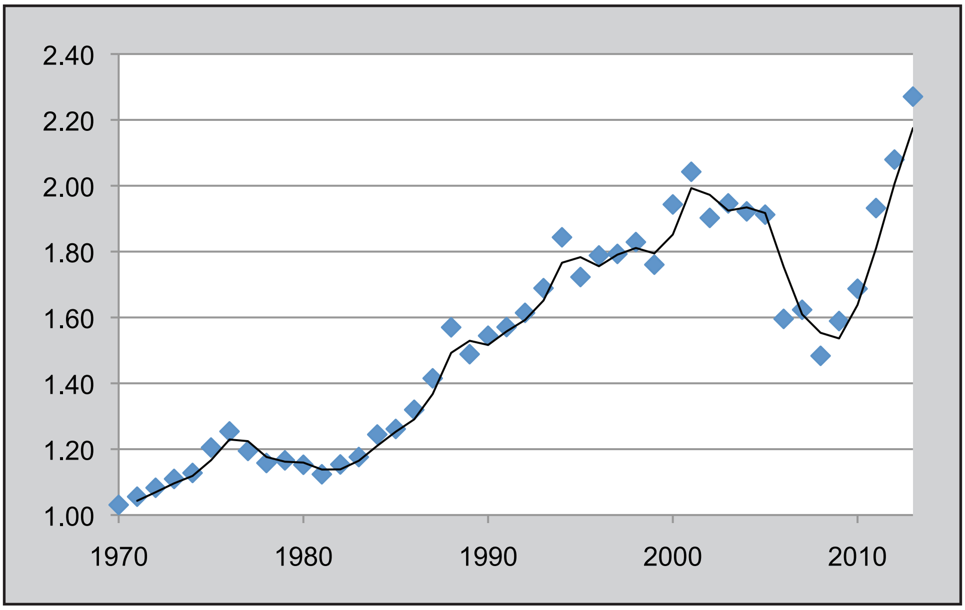

Figure 1. Trends in barley productivity (t/ha) in South Australia shown as the five year mean of state grain yield (Source ABARE).

present. Various combinations of ameliorated fertiliser, seed treatments and foliar fungicides provided an effective control of net form net blotch, but there were also examples of inadequate control strategies that resulted in significant production losses. In lower rainfall environments, particularly mallee regions, spot form of net blotch infection was prevalent and in some cases extreme. Spot form of net blotch is sometimes considered a 'cosmetic' disease with fungicide treatment at moderate levels of infection not always providing an economic response. Severe infection in susceptible varieties was observed with significant negative effects on straw strength, grain size and yield. Current varieties range from SVS to MR, so there are good levels of resistance to spot form of net blotch available and this may be important to consider in areas where there has been a history of infection and likely to be a high inoculum load.

Most of South Australia's cropping regions recorded below average rainfall in October and November and maximum temperatures were significantly above average in September and October. The very high evaporative demand generally resulted in higher screenings and lower retention values than seen in recent years and a reduced proportion of the crop achieving malt1 specification.

2013 NVT results

Seeding dates for National Variety Trials ranged from 10th May at Piednippie to 9th June at Turretfield, but were mostly sown in mid to late May. All trials returned statistically acceptable results with the exception of Wharminda which was abandoned due to storm damage and severe head loss. Site mean yield ranged from 1.42 t/ha at Lameroo, to 5.63 t/ha at Bordertown, with an average across the state of 3.70 t/ha compared to 3.34 t/ha in 2012. A total of 39 barley varieties and advanced breeding lines were evaluated in the 2013 NVT trial series. Although pressure from net form of net blotch, spot form of net blotch and late leaf rust infection was high in many districts, these diseases were effectively controlled and are not significant factors to be considered when interpreting 2013 season NVT results.

Table 1. Mean grain yield for named varieties in 2013 NVT as a function of the district mean is shown for each region. The three highest yield values in each region are highlighted in bold and underlined

	Upper Eyre Peninsula	Lower Eyre Peninsula	Yorke Peninsula	Mid North	Murray Mallee	South East
FEED						
Barque			94			
Fathom$^{\phi}$	111	107	107	110	108	98
Fleet$^{\phi}$	107	98	103	105	**112**	102
Keel	**113**	104	106	104	**110**	95
Maritime$^{\phi}$	97	96	102	94	94	90
Oxford	102	106	101	100	99	**108**
MALTING / FOOD*						
Bass$^{\phi}$	101	**110**	106	103	87	106
Buloke$^{\phi}$	98	99	102	99	96	94
Charger$^{\phi}$		98	99	99		104
Commander$^{\phi}$	100	103	105	106	104	102
Flagship$^{\phi}$	96	90	92	91	107	89
Gairdner$^{\phi}$		92	87	88		91
GrangeR$^{\phi}$	103	100	105	102	101	106
Hindmarsh*$^{\phi}$	103	109	**111**	**114**	104	101
Navigator$^{\phi}$			99	99		**109**
Schooner	86	93	86	89	84	84
Scope$^{\phi}$	91	96	100	97	99	93
Sloop SA$^{\phi}$		86	86	95	93	88
Westminster$^{\phi}$		92	96	92		101
UNDERGOING ACCREDITATION						
Compass$^{\phi}$	**113**	**114**	**115**	**116**	**115**	**107**
Flinders$^{\phi}$	97	105	99	93	96	101
La Trobe$^{\phi}$	**114**	**113**	**112**	**115**	102	**107**
Macquarie$^{\phi}$		83	90	93		104
Skipper$^{\phi}$	108	108	107	107	104	101
SY Rattler$^{\phi}$				99		97
Wimmera$^{\phi}$		101	98	97		**107**
Regional Mean (t/ha)	2.88	4.30	4.27	3.64	2.34	5.48

The relative performance of named varieties in 2013 NVT is summarised in Table 1. The grain yield for each variety is expressed as a percentage of the regional mean yield. The mean values are a reasonable guide to the general performance of varieties across the state however results in individual trials do vary. In 2010 and 2011 later maturing types such as the feed variety Oxford dominated grain yield results in many regions of SA whereas the drier spring of 2012 favoured earlier maturity types and Fathom⁽ᵇ⁾ was the leading variety.

Among the existing varieties Hindmarsh⁽ᵇ⁾, Fleet⁽ᵇ⁾ and Commander⁽ᵇ⁾ generally performed well again in 2013, while a mixture of old and new varieties also featured in the top rankings in different regions. Keel was particularly strong across the Upper Eyre Peninsula trials where very early maturity was an advantage, and at the other end of the yield spectrum Capstan⁽ᵇ⁾ returned the highest individual grain yield result with 6.5 t/ha at Bordertown, around half a tonne higher than the next variety. The new malting variety Bass⁽ᵇ⁾ was competitive across all regions but returned particularly impressive grain yield results from Lower Eyre Peninsula, while the new malting variety Navigator⁽ᵇ⁾ provided the highest grain yield across the South East trials.

GrangeR⁽ᵇ⁾, Scope⁽ᵇ⁾ and Westminster⁽ᵇ⁾ were awarded malting accreditation by Barley Australia in March 2013. Scope⁽ᵇ⁾ and GrangeR⁽ᵇ⁾ were included in all SA NVT sites and have now completed five years of evaluation. Westminster⁽ᵇ⁾ is a late maturing variety and is included in trials at higher rainfall locations and has now been tested in NVT for six years. All three varieties now have extensive performance data to demonstrate their adaptation. Table 1 includes grain yield results for seven varieties undergoing malting accreditation. Other lines currently undergoing accreditation are Admiral⁽ᵇ⁾ (WI4259) and Litmus⁽ᵇ⁾ (WABAR2625). Details on the accreditation process and updates on the progress of lines under evaluation are available at http://www.barleyaustralia.com.au

Among the new options Compass⁽ᵇ⁾ and La Trobe⁽ᵇ⁾ stand out in terms of high grain yield across a range of environments. La Trobe⁽ᵇ⁾ is agronomically very similar to Hindmarsh⁽ᵇ⁾ however, in 2013 trials it showed markedly higher grain yield on Eyre Peninsula and the South East. In previous seasons it has been more similar to Hindmarsh⁽ᵇ⁾ however, any deviation in grain yield has tended to be in favour of La Trobe⁽ᵇ⁾. In 2013 trials at Elliston, Minnipa, Bute and Bordertown La Trobe⁽ᵇ⁾ was around 400 kg/ha higher in grain yield than Hindmarsh⁽ᵇ⁾. Compass⁽ᵇ⁾ is mid maturity and more similar to Commander⁽ᵇ⁾ in plant type but was among the highest yielding varieties in all regions as shown in Table 1 despite the early finish to the season.

Season 2013 provided a good test for the physical grain quality of varieties within NVT. Test weight values were generally high with a state average of 68 kg/hL although Wanilla, Darke Peak and Turretfield averaged below the 65 kg/hL requirement for malt1. Grain protein averaged 11.3% across the SA trials but ranged from 8.3% at Crystal Brook to 14.8% at Lameroo. However, unlike recent years there was significant pressure on grain size with screenings (% < 2.2mm) for Gairdner⁽ᵇ⁾ ranging up to 35% and retention (% > 2.8mm) ranging down to 13%. The grain size information from 2013 NVT is summarised in Table 2 which lists the regional mean values for grain plumpness for each variety. Individual trial results for all characteristics are available from www.nvtonline.com.au.

Grain size results from 2013 for the established varieties were consistent with their performance in previous dry spring conditions. Schooner and SloopSA⁽ᵇ⁾ were generally good while Gairdner⁽ᵇ⁾ was poor in many trials. As a group the feed varieties generally show lower screenings and better grain plumpness than the malting options, with leading results from Maritime⁽ᵇ⁾ and Fathom⁽ᵇ⁾. Buloke⁽ᵇ⁾ and Scope⁽ᵇ⁾ were often below the 70% retention limit for malt1 while Commander⁽ᵇ⁾ was significantly better. Among the new varieties Bass⁽ᵇ⁾ reinforced its reputation for excellent physical grain quality being among the top group for screenings, test weight and retention at all sites. Navigator⁽ᵇ⁾ also exhibited very good grain size despite its relatively late maturity. Hindmarsh⁽ᵇ⁾ has a proven track record in reliably meeting Feed1 screenings levels but with increasing opportunities to market Hindmarsh⁽ᵇ⁾ above the feed grades it is timely to consider

Table 2. Mean retention values (% > 2.8mm) by region for named varieties in 2013 NVT. Only varieties tested in all trials within a region are included. The three highest values in each region are highlighted in bold and underlined

	Upper Eyre Peninsula	Lower Eyre Peninsula	Yorke Peninsula	Mid North	Murray Mallee	South East
FEED						
Barque⁽ᵈ⁾			86			
Fathom⁽ᵈ⁾	66	79	88	**88**	**91**	**97**
Fleet⁽ᵈ⁾	58	77	87	81	87	94
Keel	72	**87**	**91**	78	89	94
Maritime⁽ᵈ⁾	**83**	75	**91**	85	**93**	96
Oxford	42	47	72	54	59	90
MALTING / FOOD*						
Bass⁽ᵈ⁾	**70**	78	**91**	80	88	**99**
Buloke	43	60	70	63	70	91
Charger⁽ᵈ⁾		70	82	68		91
Commander⁽ᵈ⁾	56	74	87	81	83	96
Flagship⁽ᵈ⁾	52	73	84	65	78	87
Gairdner⁽ᵈ⁾		51	67	45		85
GrangeR⁽ᵈ⁾	61	66	87	67	82	91
Hindmarsh⁽ᵈ⁾*	52	72	83	74	82	89
Navigator⁽ᵈ⁾		**88**	84	74		**97**
Schooner	58	80	89	73	76	95
Scope⁽ᵈ⁾	44	67	71	62	76	93
Sloop SA⁽ᵈ⁾		81	90	79	81	**97**
Westminster⁽ᵈ⁾		71	87	74		96
UNDERGOING ACCREDITATION						
Compass⁽ᵈ⁾	**77**	**82**	**93**	**89**	**93**	**97**
Flinders⁽ᵈ⁾	59	64	79	70	79	**97**
La Trobe⁽ᵈ⁾	50	71	81	70	78	86
Macquarie⁽ᵈ⁾		29	50	39		81
Skipper⁽ᵈ⁾	68	74	**92**	**86**	**91**	95
SY Rattler⁽ᵈ⁾				66		88
Wimmera⁽ᵈ⁾		57	83	64		92
Regional Mean (% > 2.8mm)	58	69	83	70	81	92

Table 3. Long-term summary of safety rating and potential % yield loss for barley varieties to various herbicides and tank mixes. (SA data from Kybunga district)

Variety	Buloke(D)	Commander(D)	Flagship(D)	Fleet(D)	Hindmarsh(D)	Keel	Maritime(D)	Oxford(D)	Scope(D)	Rates (product/ha)	Crop stage at spraying
Years tested	**2006-2009**	**2005-2007**	**2004-2009**	**2004-2006**	**2007-2009**	**1998-2001**	**2003-2005**	**2009-2012**	**2010-2012**		
2,4-D Amine 625	✓(4)	✓(3)	**10** (1/6)	✓(3)	✓(3)	✓(4)	✓(3)	✓(2)	✓(2)	1.4L	2 node
Achieve®	**N** (1/4)	✓(3)	**5** (1/6)	**N** (1/3)	✓(3)	✓(4)	**N** (1/3)	✓(1)	-	380g	4 leaf
Affinity®	**12** (1/4)	✓(2)	**N** (1/4)	✓(1)	**N** (1/3)	-	-	✓(2)	✓(2)	60g	4 leaf
Ally®	**N** (1/4)	✓(3)	✓(6)	✓(3)	**N** (2/3)	✓(4)	**N** (1/3)	✓(2)	✓(2)	7g	4 leaf
Axial®	✓(4)	✓(2)	**N** (1/4)	✓(1)	**11** (1/3)	-	-	✓(2)	**9** (1/4)	250mL	4 leaf
Banvel M®	**N** (1/4)	**N** (2/3)	**16** (1/6)	**5** (1/3)	**8** (1/3)	**4** (1/4)	✓(3)	**N** (1/4)	✓(2)	1.4L	6 leaf
Boxer Gold®	✓(1)	-	**6** (1/1)	-	✓(1)	-	-	✓(2)	✓(2)	2.5L	IBS
Broadstrike®	✓(4)	✓(3)	✓(6)	✓(3)	**N** (1/3)	✓(4)	**5** (1/3)	✓(2)	✓(2)	25g	6 leaf
Bromoxynil/ MCPA	**10** (1/4)	✓(3)	**12** (1/6)	**N** (1/3)	**6** (1/3)	**3-8** (2/4)	**N** (1/3)	✓(2)	✓(2)	1.4L	4 leaf
Cadence®	**9-11** (2/4)	**12** (1/2)	**14** (1/4)	**N** (1/1)	✓(3)	-	-	✓(2)	✓(2)	200g	6 leaf
Decision®	**12** (1/4)	✓(3)	✓(5)	**N** (1/2)	**7** (1/3)	-	✓(1)	✓(2)	✓(2)	1.0L	4 leaf
Diuron/MCPA	**13** (1/4)	✓(3)	**N** (1/6)	**7** (1/3)	**10** (1/3)	✓(4)	**N** (2/3)	✓(2)	✓(2)	500mL/ 350ml	4 leaf
Glean®	✓(2)	✓(3)	✓(4)	✓(3)	✓(1)	**N** (1/3)	**N** (1/3)	✓(1)	-	20g	4 leaf
LVE MCPA	✓(3)	✓(3)	✓(5)	✓(3)	✓(2)	**4** (1/4)	**4** (1/3)	-	-	1.2L	6 leaf
Terbutryn	-	✓(1)	**N** (1/2)	**N** (1/2)	-	✓(4)	**4-7** (2/3)	-	-	850mL	4 leaf
Tigrex®	✓(4)	✓(3)	**8** (1/6)	**7-8** (2/3)	**8** (1/3)	**4-6** (3/4)	**7** (1/3)	✓(2)	✓(2)	1L	6 leaf

X-y% (w/z)	*Significant yield reductions at recommended rate in w years out of z years tested. eg 6-10 (2/4) is yield losses of 6 to 10% in 2 out of 4 years tested*
x% (w/z)	*Significant yield reduction at recommended rate in 1 trial only in z years of testing eg 8 (1/2) is 8% yield loss in 1 out of 2 years tested*
N (w/z)	*Narrow safety margin – yield loss at higher than recommended herbicide rate only w years of z years tested*
✓(z)	*no yield loss during z years of testing*

retention values in comparison to other malting options as shown in Table 2. In areas with heavy pressure on grain size such as Eyre Peninsula and the Mid North the plumpness values for Hindmarsh⊕ are generally lower than Commander⊕, reducing its probability of achieving premium prices. The trial at Turretfield experienced severe pressure on grain size and produced the highest average screenings at 18%. Among the feed varieties Fathom⊕, Fleet⊕ and Maritime⊕ achieved less than 10% screenings while Compass⊕ and Skipper⊕ met the 70% retention limit for malt1. The regional mean values in Table 2 show excellent grain size for Skipper⊕ compared to current malting varieties and Compass⊕ may replace Maritime⊕ as the benchmark for low screenings and high retention.

Barley variety herbicide tolerance update

(Project Officer: Michael Zerner, SARDI)

Within herbicide by varietal tolerance trials conducted in the Kybunga district over many seasons, barley varieties have generally not shown herbicide intolerance (measured by yield loss) to the extent of that seen in wheat varieties. However the herbicides Cadence®, Banvel®, Tigrex® and Bromoxynil/MCPA have commonly caused some yield loss and as Table 3 highlights, Cadence® on Buloke⊕, Tigrex® on Fleet⊕ and Tigrex® and Bromoxinyl/MCPA on Keel have been some of the more sensitive combinations over time.

Despite not being present in Table 3, recently released varieties such as Fathom⊕, Flinders⊕, Navigator⊕, Skipper⊕ and Wimmera⊕ have undergone preliminary testing. Fathom⊕ has shown some increased level of sensitivity to Broadstrike® and dicamba than other varieties when applied at rates exceeding label recommendations. Further information on these newer varieties can be accessed via the NVT website.

These data can be used to identify herbicide by variety combinations which minimise yield loss and best suit individual farming practices, primarily to obtain weed and herbicide resistance control. Information on varieties which have been tested in one year only should be treated with caution pending further trials. This research aims to evaluate all new varieties in the NVT program. For more extensive information please visit NVT Online www.nvtonline.com.au or contact project officer, Michael Zerner SARDI on ph 83039479.

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Notes

Do we need to revisit potassium?

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Keywords

4R nutrient stewardship, potassium, soil tests, tissue tests, Colwell-K

Take home messages

- **Potassium is one of the essential macronutrients, along with nitrogen, phosphorus and sulphur.**
- **Sandy, acid soils in high rainfall areas are most prone to potassium deficiency, particularly if cut for hay.**
- **Critical Colwell-K soil test ranges have been better defined for wheat, canola and lupins from the Better Fertilizer Decisions project.**
- **Sample depth, soil cation exchange capacity, yield potential, soil water content, row width, presence of other cations and crop species all affect the critical soil test range.**

Potassium in soils and plants

As management improves and yields increase, the extraction and relocation of nutrients also increases. Regional nutrient budgets show a progressive drawdown of potassium (K) as it is removed in plant products and, depending on cropping system and soils, there may be a need to consider the role of K. Use of K in Australia declined from 183 kt K in 2003 to 149 kt K in 2011 but did recover somewhat in 2012. At present around 75 per cent of the K used is muriate of potash (MOP), also called sylvite (KCl) and about one third is used in WA, one third in Queensland and the balance across the other states.

Potassium is a mineral nutrient essential to both plants and animals. Most of our annual crops contain about the same amounts of N and K, but the K content of many high-yielding crops can demand more K than N.

Unlike other nutrients, K does not form compounds in plants, but remains free in ionic form to 'regulate' many essential processes including enzyme activation, photosynthesis, water use efficiency, starch formation and protein synthesis. Potassium plays a significant role in stomatal control so adequate K is often associated with some drought tolerance and small grain can be a consequence of deficiency. Within general limits, neither grain protein (cereals) nor oil content (canola) are affected by K supply.

Table1. Potassium uptake by crops (Brennan pers. comm., Reuter pers. comm.)

Crop use	N uptake kg/t	K content kg/t	Yield t/ha	K removal kg/ha
Wheat growth	25			
Wheat grain		5	3	15
Wheat straw		15	5	75
Wheat hay		20	6	120
Canola growth	30			
Canola grain		10	2	20
Canola straw		25	4	14
Canola hay		35	5	175

In South Australia about 10 per cent of the top 10 centimetre soil test values were less than a general lower limit of 100 mg/kg Colwell K, so the deficiency is not widespread. Low soil K values are predominately on the sandy grazing soils of the south east region (especially along the Coorong), parts of the Mount Lofty Ranges, Kangaroo Island and southern Mallee regions. Soils with marginal status are sandier soils on Eyre Peninsula region. Consistently high values were observed in the northern and Yorke Peninsula cropping regions (Australian Agricultural Assessment 2001).

Table 1 shows K contents in wheat and canola crops cut for hay or left for grain. The K content of hay is much higher than the K content of grain, and the biomass in a hay crop will be more than the mass of grain removed as well. Therefore, around ten times more K will be removed in hay than grain.

Potassium concentration in the stubble of both canola and wheat is higher than in the seed and if the stubble is burned 30 to 40 per cent of this K will be lost (Heard et al. 2006). If the stubble is retained, a lot of the K will be recycled through the topsoil and, unless the straw is spread, can accumulate under the windrows. This is a reasonable field observation to diagnose K limitation.

As well as the amount of K demanded, the pattern of K uptake varies among crops. Some crops like maize take up 50 per cent of its K when it has accumulated only 30 per cent of its peak biomass. In this crop, early K supply is important and early K stress cannot be remedied by tactical K applications. Rose et al. (2006) found that maximum K accumulation in wheat was around anthesis, but canola peaked a little later and had around 20 per cent more K than wheat. Because K demand is quite high early, it should be applied early rather than later and applications at booting in wheat or bud formation in canola are ineffective. Lupins are less responsive to applied K than either wheat or canola (Brennan 2012) and this is reflected in the lower critical Colwell K values (Table 2). Horticultural crops such as potatoes have very high demands.

Plants take up K actively and there are two mechanisms that operate depending on K concentration. Competition for uptake occurs between K and other monovalent ions such as sodium, and also between K, calcium and magnesium. The result can be low tissue Mg which in grazed pastures can induce grass tetany (if soil K/(Ca+Mg) is less than 0.07, grass tetany is likely). The interactions among cations are quite complex and Na can replace part of the K demand of crops in mildly stressed cereals (Ma et al. 2011).

Potassium deficiency symptoms

One of the most common K deficiency symptoms is scorching or firing along leaf margins, usually appearing on older leaves first. Potassium deficient plants grow slowly and develop poor root systems. Stalks are weak and lodging is common. Crops show lower resis¬tance to disease and moisture stress.

Potassium in soils

Most soils contain large amounts of K, which is present in clay minerals such as smectites which are rich in K. However, probably less than 2 per cent of the total soil K content is available to plants over the growing season as most of it is a structural part of the clays.

K exists in four forms:

- **Structural K** held in the lattice of soil minerals such as micas and feldspars. This is unavailable except over geologic time scales.
- **Fixed or interlayer K** is trapped between layers of certain soil clays. This K is only very slowly available. The availability of this fraction is least reliably measured in soil tests, but it is the fraction that can be slowly depleted over time. This depletion will not show up in exchangeable or solution K soil tests.
- **Exchangeable K** is present on the surface of clay and organic colloids and the size of this fraction depends on the CEC of the soil as well as its pH. K is displaced in acid soils.
- **Solution K** is found in soil water and moves by diffusion to the plant root.

Plant available K is present as a cation in soil solution or in the clay complex and can be accessed by roots through diffusion. This can be a slow process. Alternatively uptake can occur when crop roots contact soil colloids where K is held, but only a small proportion of the soil contacted. Figure 1 illustrates the way K diffuses to plant roots. This transfer process can result in restricted supply to high demanding crops.

Because of the way K moves and is taken up, there are several things that cause problems when trying to predict K responsiveness using soil tests.

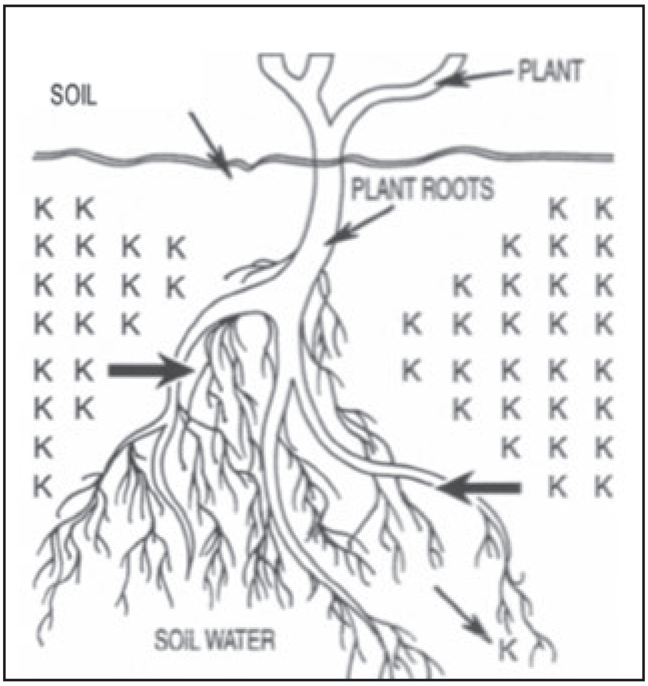

Figure 1. Potassium moves to plant roots either by slow diffusion or is taken up directly in exchange with soil colloids. Both can be slow processes.

1. Because K is diffusion limited, wetted soil is critical for uptake and if the top soil or sub-soil is dry, K will not be able to be accessed.
2. Under high-yielding condition, K diffusion can be slow and may not meet the rate at which it is demanded by the crop.
3. Rooting patterns differ among crops and tap rooted plants can be at a disadvantage in exploiting K compared to fibrous rooted plants. Row width can also change rooting patterns so wide seeding rows can reduce the volume of soil exploited.
4. Different species have different K demands. Wheat demand is a little lower than canola and cotton tends be a lot higher. Data from India indicates that chickpeas, peas and lentils have a higher demand than wheat (Srinivasarao et al. 2003), while lupins have a lower demand or are better able to access soil K (Brennan and Bell 2013).

5. Other cations can affect the K demand by either competition or partial substitution as well as through soil physical disruption.

Soil tests to predict crop response

As for other nutrients, soil tests seek to estimate the amount of K available to the plant using various extractants. Exchangeable K is estimated using ammonium acetate, while extractable K is estimated using bicarbonate (Colwell-K) or weak acid (Skene-K) and techniques using resins or exchange membranes are under development. There is a general relationship between Colwell K and exchangeable K, and for light soils the latter can be converted to the former by a factor of 391. However, extractable K can be more than exchangeable K on heavier soils. Mehlich-3 is a multi-element extractant used in the US but there is little data to support its use diagnostically in Australia. Tetraphenyl borate extractable K (TB-K) has been used to estimate the amount of K in the slowly available pools and can help identify the amount of 'back-up' available. It can also be interpreted as a potential K buffering capacity. In the US there have been tests proposed using moist rather than dried soils.

Predicting K response using soil tests is reasonably reliable for sandier soils, but on heavier soils the reliability declines. The search for more reliable soil K tests is a challenge and there have been concerns raised about the use of current tests (Khan et al. 2013). The Better Fertilizer Decisions for Crops (BFDC) project developed critical soil test ranges for a range of crops for Colwell-K (Table 2).

Table 2. Critical 0 to 10 cm Colwell-K soil test ranges (Brennan and Bell 2013) for a range of soil orders (values in mg/kg). Values are the 95 per cent confidence range to achieve 90 per cent of maximum yield

Soil	Wheat	Canola	Lupin
All Soils	**41-49**	**43-47**	**22-28**
Chromosols	35-45		
Ferrosols (Brown)	57-70		
Kandosols	45-52		
Tenosols	32-52	44-49	22-27
Tenosols 2-3 t/ha	37-48		
Tenosols > 3 t/ha	51-57		

The data were skewed to Western Australia and the values for heavy soils still seem relatively unreliable.

Research in SA for sunflower by Lewis et al. (1991) proposed a critical value of 65 mg/kg, which was similar to the broad range from the BFDC project. Research in the northern cropping zone has shown that K is becoming depleted, particularly in the subsoil, mainly because root growth in winter crops occurs below dry or drying topsoil. Deeper soil tests (to 30 cm) and estimates of buffering capacity and associated cations can help redefine critical limits. Table 3 shows the expected effects of CEC, profile and other cations on critical soil test values. Deeper sampling is also being used in Western Australia where K can leach on the coarse acid soils and the approach gave clearer critical values for wheat and canola than 0 to 10 cm sampling (Anderson et al. 2013).

Table 3. Effect of CEC, depth and companion ions of tentative estimates of wheat critical K levels for northern Vertosols (Guppy, pers.comm.). Values are those cited by Guppy as exchangeable K (ex-K) and converted to Colwell K. *High Mg > 30 per cent CEC, High Na > 6 per cent CEC

CEC	Topsoil (0-10 cm)		Subsoil (10-30 cm)	
	Ex-K (mg/kg)	If High Mg/Na*	Ex-K (mg/kg)	If high Mg/Na*
< 30 cmol/kg	80	160	40	80
30-60 cmol/kg	160	240	120	200
> 60 cmol/kg	200	400	200	310

Critical Colwell K values for pastures are higher than the values in Table 2 and have been interpreted in terms of soil texture. Values range from 125 mg/kg in sands to 160 mg/kg in clay loams (Gourley et al. 2007).

Because of these interactions, it is difficult to reliably estimate K critical soil test values especially on vertosol soils. The reason is that the rate of supply from less available K pools may be insufficient where rooting patterns or slow diffusion limits supply to a crop that experiences a period of high demand.

Plant tissue tests

As for some other nutrients, plant nutrient status can be assessed through tissues tests. The tests need to be timed to critical periods and the tissue selected needs to be responsive. The critical K concentration for the youngest emerged leaf blade at tillering in wheat is around 2 per cent and about 1.8 per cent in the youngest mature leaf during vegetative growth for canola (Reuter and Robinson, 1997). Concentration declines with later timings and with whole tops rather than blades.

Grain K content is not a reliable indicator of paddock K status. Many plants show 'luxury' accumulation of K and so high values are not necessarily evidence of any toxicity.

Addressing potassium deficiency

Timing, placement and rate of application all affect the response to K. Naturally, it is critical to ensure that K is the limiting factor and there are interactions among N, P, K and S as well as micronutrients. South Australian research showed that if N and P requirements were met, then added K gave good responses (Figure 2).

The right time and ***right place*** to give the best K response is at seeding rather than topdressing. Muriate of potash is a salt and can cause damage to sensitive seeds when place together in the sowing row. The amount of damage will depend on row width, seeding points, soil texture and moisture. There is more information and access to the on-line damage tool at http://anz.ipni.net/article/ANZ-3076. Banding below the seed at planting has been shown to give much better results than topdressing or pre-spreading (Wilhelm 2003, Figure 3).

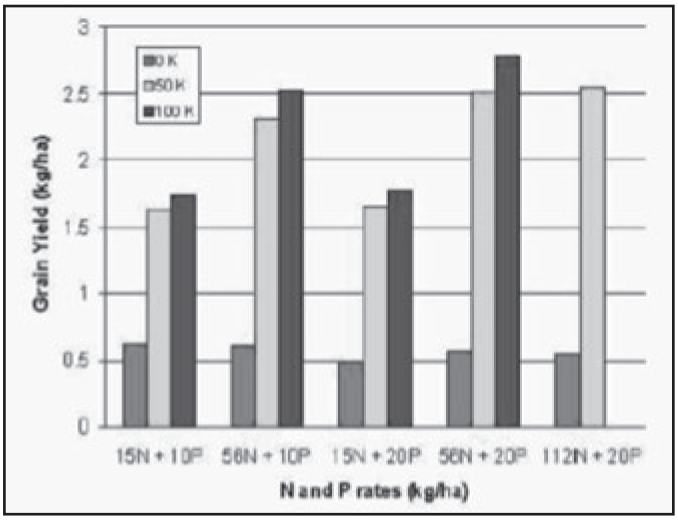

Figure 2. Grain yield response to the application of K at various N and P rates (Wilhelm, 2003). The soil Colwell K was 43 mg/kg in topsoil and 69 mg/kg in the subsoil.

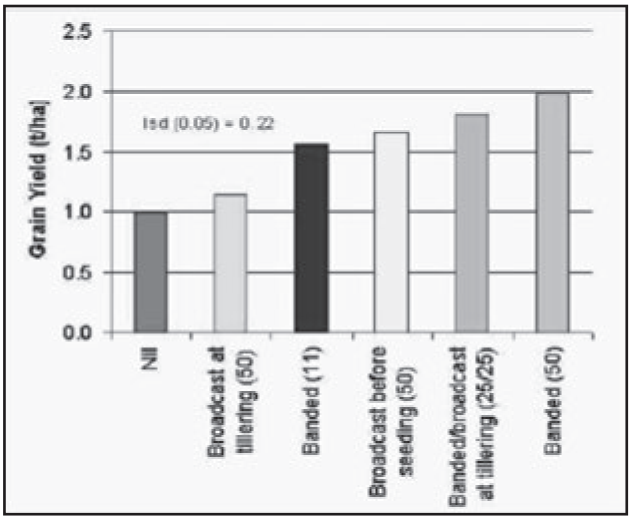

Figure 3. Wheat grain yield in response to 50 kg K/ha with different application techniques (Wilhelm 2003). Soil Colwell K was 121 mg/kg in topsoil and 53 mg/kg in the subsoil.

The right rate will need to be higher than replacement because K is relatively immobile. If the K buffering capacity is high, and the non-exchangeable K pool is strongly depleted, the competition between the soil and plant can mean minimum rates of 50 to 100 kg K/ha are needed to see responses. If using test-strips run out at seeding, use a high rate to see if K supply is adequate.

Another consequence of the low mobility, especially in alkaline soils, is that high rates can be used to cover two or three or even more crops. Work in Queensland uses 200 kg K/ha deep (20 cm) banded before the most responsive crops and is then cropped down over the seasons. So, it is better to use higher rates less frequently than lower rates every year.

The right source is usually MOP, mainly because it is significantly cheaper than sulfate of potash, potassium nitrate or potassium magnesium sulfate (langbenite). All commercially available K fertilisers are imported, although there is one current development to exploit greensand deposits of glauconite in WA. Some growers are concerned about adding extra chloride, but the amounts added are of little agronomic or environmental significance in adding to salt loads.

Conclusions

- Potassium deficiency has been confirmed in South Australia in grain cropping regions.
- As K reserves are drawn down with higher yields, K replacement may need to be more widely addressed, as it has been in Western Australia.
- The first evidence could be seen as good growth in windrows.
- Soil tests are reliable on sandy soils but less so on heavy soils.
- Responses to 50 to 100 kg K/ha banded below the seed at seeding where soil tests are below critical concentrations should give economic responses.

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Cereal disease update - South Australia 2014

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GRDC project code: DAS00099; DAS00139; SAGIT S1206

Keywords

wheat, barley, net blotch, white grain, crown rot, eyespot, take-all

Take home messages

- **As varieties and management systems change, cereal pathogens are also evolving and changing in importance.**
- **Seasonal conditions are critical in determining whether crop damage is likely to occur.**

Net form net blotch (NFNB)

Net form net blotch continues to cause problems in many barley crops. In some areas growers are treating crops with fungicides from very early growth stages and finding that this form of protection is most effective. A particular concern with NFNB is the continuing rapid evolution of virulence in this pathogen with Keel, Maritimeɸ, Fleetɸ and Oxford showing rapid falls in resistance rating in recent years.

In 2013 the main feature of the epidemic was the severe virulence on Fleetɸ in many areas. Until 2012, Fleetɸ was largely very resistant but isolated crops at Urania and south of Port Pirie showed high levels of infection. Extensive testing of isolates of the fungus taken across SA in recent years has shown that none of the strains tested have combined virulence on Fleetɸ and Maritimeɸ so in some areas Maritimeɸ may have appeared as quite resistant. However, virulence on Maritimeɸ remains present in areas where this variety is still grown. Virulence on Commanderɸ, Fathomɸ and Navigatorɸ was also very common. Two Fleet isolates from Wokurna and near Pt Broughton also showed virulence on Oxford, Skipperɸ, SY Rattlerɸ, Westminsterɸ and Wimmeraɸ. In contrast, Bulokeɸ, Grange Rɸ, Hindmarshɸ, Scopeɸ, Schooner and Sloop SAɸ have shown consistently good resistance so far. Compassɸ has shown good resistance in the field but testing in controlled conditions indicates that some isolates cause moderate susceptibility.

In future improved control of this pathogen is most likely to come from new seed treatments but it remains most important that the more susceptible varieties are not grown in areas or situations prone to the disease as this only facilitates the further evolution of the fungus.

Spot form net blotch (SFNB)

NVT trials over many years have indicated that spot form net blotch causes little damage to barley crops except where the most susceptible varieties are grown in the most prone situations. It therefore came as a surprise that some crops, notably Hindmarsh⦶, saw severe infection levels in some areas that most likely led to significant yield losses. Of particular concern were Scope⦶ crops around Loxton and Cleve that showed susceptibility similar to Hindmarsh⦶ (S) whereas in previous years, and at most NVT sites in 2013, Scope⦶ has rated as only moderately susceptible. It is likely that there has been a shift in virulence in this pathogen leading to increased virulence on Scope⦶ and presumably Buloke⦶. This is currently being tested in controlled environment conditions on the Waite Campus.

It is most likely that SFNB was more severe in 2013 because of the widespread cultivation of Hindmarsh⦶ combined with the warm conditions in May and subsequently a warmer and wetter winter than usual.

White grain

White grain was not detected in deliveries to silos in 2013 and there was only one report from upper Eyre Peninsula of grain retained on-farm for feed which had very low levels of white grain. The absence of white grain was likely due to most spore release occurring prior to head emergence (Figure 1) and relatively low humidity conditions from head emergence to the end of grainfill in areas prone to this problem.

Also as a result of the dry spring, there were no obvious white grain symptoms in the SAGIT variety screening trials on upper Eyre Peninsula. Similarly there were no symptoms of white grain in any of the NVT trials sown in SA. This means we still have no indication of the resistance levels of current cultivars or of possible sources for resistance genes. We artificially inoculated pot trials on the Terraces at the Plant Research Centre in 2013 and although we have not yet processed the samples, preliminary assessment suggests artificial inoculation may provide an avenue for future resistance screening.

Identification of symptoms of infection by the white grain fungi in green cereal heads is possible but not easy in the field due to their similarity to symptoms of frost damage.

Traps at Buckleboo on upper Eyre Peninsula indicate that spores were released from stubbles from the first week in August to the first week in September, but were not present in significant numbers after that (Figure 1). Trends in spore release were similar for both sites (approximately one kilometer apart) which were monitored, although spore numbers were lower in the paddock where there had been a break from cereal in 2011. This indicates that a break from cereal will contribute to reduced infection levels and that spore trap results could be used prior to harvest to predict the risk of white grain in crops.

Crown rot and take-all

Good spring rainfall in 2011 and 2012, together with dry summers contributed to an increase in crown rot and take-all in 2013. It will be important to know the levels of these diseases in paddocks at the start of 2014 to plan management which reduces the risk of yield loss from crown rot and take-all in cereal crops this season.

Crown rot was favored by high levels of inoculum carried over from 2012 followed by ideal conditions for infection at the start of 2013. Relatively dry conditions during grain fill in many areas, particularly the upper Eyre Peninsula, resulted in white head expression and yield losses from crown rot.

Take-all appeared as a problem on upper/eastern Eyre Peninsula, particularly around Cleve, in 2013. The fungus requires wet spring conditions to build up, as occurred in 2010 and 2011. Although the dry spring in 2012 would not have increased inoculum, the dry conditions through spring and summer likely prevented break down of the inoculum. The Cleve experience is a timely reminder that it only takes

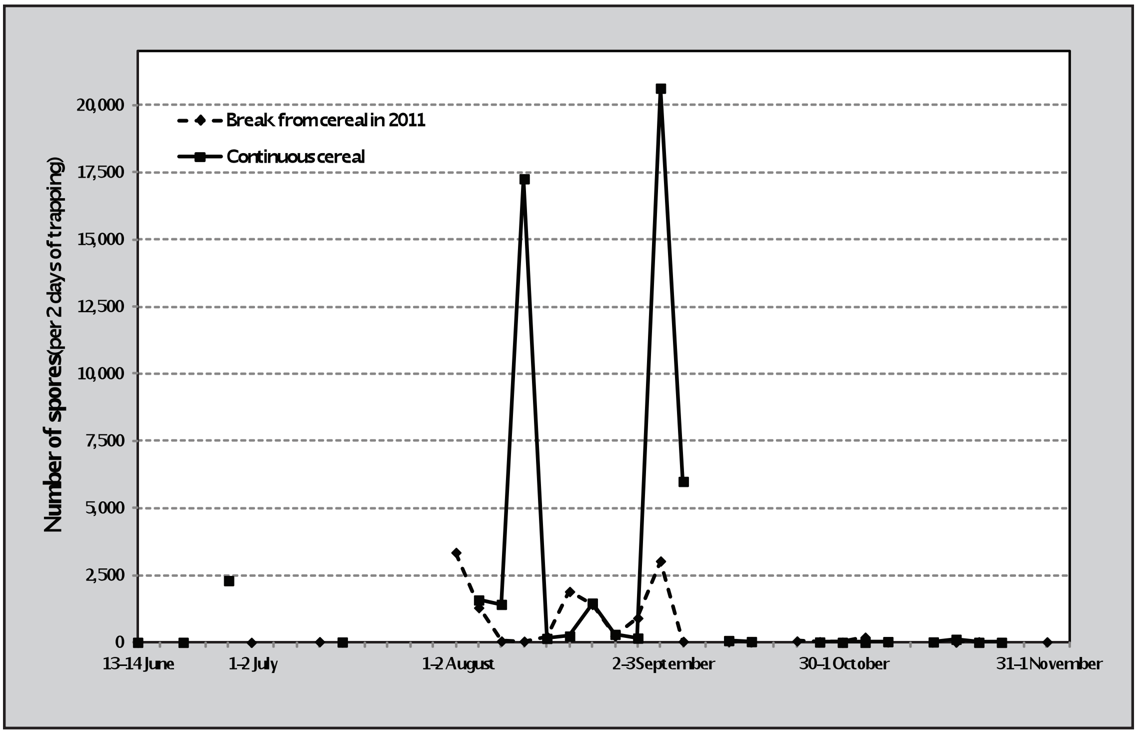

Figure 1. Presence of air-bone spores of the fungi associated with white grain in two paddocks at Buckleboo during 2013.

1-2 seasons with conducive conditions for take-all inoculum to build up to potentially damaging levels.

Eyespot

Eyespot has been increasing in recent years, mainly on the lower Eyre Peninsula and high rainfall areas of the Mid-North. Crops in the South-East are also likely to be vulnerable in the future, particularly if cereal rotations are intensified. Retention of stubbles, close rotations, thick crops, good moisture levels and high nitrogen inputs all favour the disease. Generally all varieties are susceptible although taller and weaker-stemmed varieties are likely to lodge more readily after infection. Some variation in the degree of susceptibility is likely to exist in current varieties and this will be investigated in trials funded by GRDC in 2014 and 2015.

Whilst no fungicides are currently registered for control of eyespot in Australia, some of the fungicides registered for other diseases do show good efficacy in crops in Europe. Most critical is the timing of application which needs to be around growth stage 31 and before any symptoms of eyespot are obvious. Decisions on spraying will therefore need to be made on the basis of previous incidence of eyespot, rotation and seasonal conditions.

Loose smut

Numerous Hindmarsh⊕ barley crops across southern and Western Australia showed loose smut infection. In many cases this occurred in spite of treatment with seed fungicides that should have controlled infection. Presumably Hindmarsh⊕ is too susceptible for some treatments to be effective. Tests are underway in SARDI on infected seed to determine which seed treatments are capable of providing adequate control in Hindmarsh⊕.

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Wheat variety research update for 2014

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GRDC project codes: DAS00109, DAS00100

Keywords

wheat, durum, new variety performance, National Variety Trials, herbicide tolerance

Take home messages

- **High winter rainfall and very dry spring conditions across SA in 2013, again favoured early and mid maturing wheat varieties.**
- **Corack$^{\phi}$ and Trojan$^{\phi}$ were the top yielding APW varieties and Cobra$^{\phi}$ and Mace$^{\phi}$ lead the top yielding AH varieties at the 2013 wheat NVT sites.**
- **The regular use of fungicides for stripe rust control within wheat NVT has reduced the impact of this and other fungal diseases on grain yield performance, hence placing greater importance on the use of disease guides for varietal choice. This is a further reminder of the need to minimise or avoid sowing susceptible varieties which do not meet minimum disease standards unless a vigilant and successful disease control strategy is in place.**
- **Dry spring conditions favoured the early flowering durum variety, Saintly$^{\phi}$, over Yawa$^{\phi}$ in 2013.**

2013 wheat variety performance review

In 2013, wheat variety trial yields across 24 South Australian NVT, averaged 3.4 t/ha, which was above the five year (2008-2012) average of 3.13 t/ha and the 2.69 t/ha in 2012. The individual trial site yields ranged from 1.44 t/ha at Penong, to a record 7.03 t/ha at Conmurra, with all trials sown between May 7th and June 9th. Conmurra, a new site introduced in 2012, contained a range of wheat cultivars including red and winter wheats sown either early or later appropriate to maturity groups. Due to adverse seasonal issues, results from trials at Mitchellville, Mintaro and Geranium were considered invalid due to severe wind damage and frosts, respectively at the latter two sites.

Generally average winter temperatures and average to above average winter rainfall across the State, favoured the prospects for wheat fungal diseases. However proactive control, saw little impact from stripe rust in trials and generally only yellow spot was considered yield limiting at sites such as Rudall and Pinnaroo. It must be reminded that wheat NVT's are managed for disease control, using up-front (Impact®) and in-crop fungicides where diseases are detected and have the potential to cause significant yield losses. Within many districts, well above average crop potential and dense crop canopies following winter, were subjected to high winds, frosts and low rainfall events during spring. Despite the low spring rainfall, trials produced surprisingly good yields and acceptable grain quality at most trial sites. Overall, the 2013 seasonal conditions tended to again favour early and mid flowering and maturing varieties.

Across all NVTs in SA, the early flowering APW variety Corackϕ, produced the highest average yield of 3.68 t/ha across sites, just above Trojanϕ (3.65t/ha) and 2% above both Maceϕ and Cobraϕ. Trailing these four leading varieties were Wyalkatchemϕ, Emu Rockϕ and Scoutϕ at three, four and five % below Corackϕ, respectively. These top yielding varieties were also among the highest yielding in 2011 and 2012. The relative grain yield and grain 'receival quality' performance of selected commercial varieties in 2013 NVT is summarised in Table 1. The grain yield for each variety is expressed as a percentage of the regional individual trial mean yields. The mean values are a guide to the general performance of varieties across the state however results in individual trials do vary and this detail can be found at www.nvtonline.com.au.

While Corackϕ appeared very consistently among the top four ranked varieties in most regions, Trojanϕ also classified APW and with a similar overall average, was higher yielding within most high yielding, higher rainfall environments such as the South East, Yorke and Lower Eyre Peninsula's. Just below these APW varieties on average yield were the AH varieties Cobraϕ and Maceϕ. Cobraϕ closely matched Trojanϕ's yield in higher yielding environments while Maceϕ closely matched Corackϕ in lower yielding environments but overall Corackϕ was a standout in the Mallee trials. Other varieties including Wyalkatchemϕ, Emu Rockϕ, Scoutϕ, Shieldϕ and Katanaϕ were among the top performers within individual regions while Scoutϕ, which has performed well in more recent and wetter seasons, was less dominant under the drier conditions of 2013. The older variety, Wyalkatchemϕ, continues to surprise with its consistently good performance across most seasons despite being outclassed in many disease and quality attributes. The new imidazolinone tolerant variety, Grenade CLPLUSϕ, demonstrated that it is a good alternative to Justica CL Plusϕ and Kord CL Plusϕ with equal, or superior yields in all trials. Grenade CL Plusϕ also averaged 1.8 kg/hl higher test weights than Justica CL Plusϕ, cementing its role as a suitable replacement for Justica CL Plusϕ.

When averaged across trials, varietal market 'receival quality' in terms of test weight, grain protein and grain plumpness, were generally very good, with moderate protein averaging 11.8% across sites, low to moderate screenings averaging 2.3% and high test weights averaging 82.4 kg/hl. These compared with an almost identical 11.5% protein, 2.7% screenings and 82.9 kg/hl test weight averages recorded in 2012. The issues with white grain, sprouting, and black point, seen in recent years were generally not seen as a problem in 2013 NVT.

Within trials, Corackϕ, Trojanϕ, Maceϕ, and Scoutϕ continue to show relatively low grain protein while Cobraϕ produced good protein levels for its high yield. Scoutϕ and Estocϕ continue to provide benchmark high test weights along with Trojanϕ, while more moderate test weights were recorded within Cobraϕ, Phantomϕ and Shieldϕ. Correllϕ, which in previous years has shown a propensity for low test weight, was again the lowest ranking along with the biscuit wheats, Barhamϕ and Orionϕ. The Turretfield and Warramboo trials produced low test weights which revealed some weakness in varieties which could be useful information when the new minimum milling wheat standard (test weight minimum 76 kg/ha), is introduced by GTA for the forthcoming 2014/15 harvest.

Durum wheat

Across the 5 central region durum NVT sites, (Mintaro results rejected due to frost incidence) average site yields were 3.87 t/ha, being 7 to 9% below the bread wheat site averages in the Yorke Peninsula and Mid North sites, respectively.

For the first time since 2008, Saintlyϕ was the top yielding variety across sites and Yawaϕ, which had consistently topped yields in recent years, was 7% below when averaged across five sites. Relative varietal performance was consistent across the five Mid North and Yorke Peninsula sites and there was generally less separating the top variety yields compared with previous years. Tjilkuri⊕ and Caparoi⊕ trailed Saintly⊕ by 5% on average followed by WID802⊕ and Yawa⊕ (6 - 7% respectively) and then Tamaroi and Hyperno⊕ (9 - 12%). While variety rankings were clearly impacted by the dry spring conditions favouring the early variety, Saintly⊕, quality was also impacted. The durum NVT sites generally produced disappointing quality, of mostly DR2 specification, with notable high screenings at Turretfield and low protein at Wokurna. Yawa⊕, again showed an increased propensity to produce small grain as also Hyperno⊕ and to a lesser extent Tjilkuri⊕ and WID802⊕. As seen in previous years, Caparoi⊕ produced the most consistent high quality grain meeting DR1 or DR2 standards at all sites. The average, across sites, receival quality data is presented in Table 1.

Comments on selected newer wheat varieties

(Note: quality classification based on max. eligibility for SA grades)

Corack ⊕

Corack⊕ (VW2316) is an early maturing, APW quality wheat derived from Wyalkatchem⊕. It has CCN resistance and good yellow leaf spot resistance but is moderately susceptible to leaf and stripe rust and very susceptible to powdery mildew. Long term NVT results in SA show a high yield potential, particularly in low to medium rainfall situations, with good grain quality. Seed is available through AGT (conditional Seed Sharing allowed).

Emu Rock ⊕

Emu Rock⊕ (IGW3167) is a high yielding, AH quality variety for mid to late sowings in a broad range of environments across WA. This early maturing, large grained wheat, derived from Kukri⊕, is susceptible to CCN but has moderate to good resistance to stem and stripe rust and is MSS to leaf rust and MRMS to yellow spot. Across two seasons NVT in SA, Emu Rock⊕ has shown yields aligning with Wyalkatchem⊕. Seed is available through Intergrain.

Estoc ⊕

Estoc⊕ (RAC1412) was released in late 2010 and is related to Yitpi⊕. It is a mid to late maturing variety like Yitpi⊕, moderately resistant to CCN, SVS to *P. thorne*i, with good levels of resistance to all rusts (MRMS to Yr), better yellow leaf spot (MSS) resistance and significantly higher grain yields. Estoc⊕ is eligible for APW classification, has good physical grain quality like Yitpi⊕ and has shown good sprouting tolerance. Seed is available through AGT (conditional Seed Sharing allowed).

Forrest ⊕

Forrest⊕ was released by HRZ wheats in 2011, targeting high rainfall zones, as an APW (SA) quality wheat. Forrest⊕ has late maturity and plump grain coupled with triple rust resistance, MR/MS to yellow leaf spot, MR to black point and resistance/tolerance to wheat streak mosaic virus. Forrest⊕ is susceptible to CCN and S/VS to crown rot. Forrest⊕ is commercialised by Seednet.

Grenade CL Plus ⊕

Grenade⊕ (RAC1689R) is an imidazolinone herbicide tolerant (Clearfield type) replacement for Justica CL Plus⊕. It is early to mid season flowering with moderate resistance to CCN, useful rust resistance (stem rust – MR, stripe rust (WA-Yr17) – MRMS and leaf rust - MS) and susceptible to yellow leaf spot. It has improved test weight and sprouting tolerance over Justica⊕ and an AH classification with seed available from AGT.

Longreach Cobra ⊕

Cobra⊕ (LPB07-0956) was recently released in Western Australia as an early maturing Westonia derivative with AH quality and high yield potential. Cobra⊕ has good resistance to stem and leaf rust but rated MSS to stripe rust, MRMS to CCN and MRMS to yellow leaf spot. Cobra⊕ has good grain size and moderate test weight and is moderately susceptible to pre-harvest sprouting. Seed is available through Pacific Seeds.

Table 1. Mean grain quality and yield from 2013 NVT. Yield expressed as a function of TRIAL mean yield is shown for each region. The highest four ranked varieties in each region are highlighted with bold and underlined text (varieties omitted from means were not tested at all locations, varieties listed in alphabetic order within classification grade)

Variety	SA Agricultural Region							Statewide 2013 trials mean		
	Grade	LEP	UEP	YP	MN	SE	MM	protein	Test wt	Screen
								%	kg/ha	%
AGT Katana(d)	AH	100	**106**	101	102	96	100			
Axe(d)	AH	85	93	88	104	90	94	12.4	81.9	1.4
Catalina(d)	AH		90	93	96	90	94			
Cobra(d)	AH	**111**	105	**109**	**108**	**111**	87	12.1	80.9	2.0
Correll(d)	AH	90	96	93	90	89	96	11.9	79.3	3.2
Dart(d)	AH	98	96	96	99	95	98	11.8	83.0	2.6
Emu Rock(d)	AH	101	**107**	102	**109**	100	**110**	11.9	82.7	2.4
Gladius(d)	AH	93	97	101	96	98	100	12.3	81.1	2.0
Grenade CL Plus(d)	AH	93	97	98	99	94	99	11.7	82.0	1.7
Kord CL Plus(d)	AH	90	96	96	95	91	100	12.2	81.1	2.5
Mace(d)	AH	**106**	**108**	105	**111**	102	**107**	11.2	82.6	1.7
Peake(d)		AH				99	102	100		
Phantom(d)	AH	91	91	94	94	97	87	11.8	81.0	3.2
Scout(d)	AH	105	96	**108**	107	103	101	11.2	83.9	2.3
Shield(d)	AH	100	98	99	100	93	**108**	11.6	81.0	3.5
Wallup(d)	AH		97	103	101	100				
Yitpi(d)	AH		93	88	89	91	94			
Corack(d)	APW	**110**	**106**	107	**113**	**105**	**115**	10.7	82.4	1.7
Espada(d)	APW	96	103	102	97	90	97			
Estoc(d)	APW	100	100	100	98	98	93	12.3	83.7	2.7
Harper(d)	APW			99	89	92	96			
Justica CL Plus(d)	APW	94	96	99	91	98	94	12.3	80.2	1.7
Magenta(d)	APW			91	92					
Trojan(d)	APW	**112**	104	**109**	107	**115**	102	11.2	83.1	2.2
Wyalkatchem(d)	APW	105	**107**	**108**	107	**104**	99	11.8	82.4	1.2
Impala(d)	ASFT				89	93				
Orion(d)	ASFT				82	94				
Site Mean (t/ha)		4.08	2.30	4.82	3.37	5.29	1.94	11.8	82.5	2.3
Trial Number		*3*	*6*	*3*	*3*	*4*	*5*			
Caparoi(d)	durum			100	100			13.1	82.9	1.6
Hyperno(d)	durum			96	91			13.1	78.5	8.2
Saintly(d)	durum			104	106			12.0	81.7	2.6
Tamaroi	durum			98	95			12.9	80.5	2.9
Tjilkuri(d)	durum			100	100			12.6	78.8	4.0
WID802(d)	durum			100	99			12.5	78.5	4.1
Yawa(d)	durum			97	98			12.6	78.7	7.8
Site Mean t/ha				4.40	3.15			12.7	79.9	4.5
Trial Number				*2*	*3*					

Longreach Dart φ

Dartφ (LBP07-1325) is a very early maturing, AH quality wheat with good early vigour and good resistance to all rusts and yellow leaf spot but susceptible to CCN. Dartφ shows restricted tillering and in combination with quick maturity, seeding rates should be kept up to maximise yield. Seed is available through Pacific Seeds.

Longreach Phantom φ

Phantomφ (LRPB07-1040) is a mid to late flowering, AH quality variety derived from Yitpiφ with resistance to CCN, good resistance to powdery mildew and all rusts but rated SVS to yellow leaf spot and shows mid-season "yellowing" similar to Yitpiφ. Phantomφ has good black point tolerance, boron tolerance, low screenings and acceptable test weight. Seed is available through Pacific Seeds.

Longreach Trojan φ

Trojanφ (LPB08-1799) is an APW quality variety derived from Sentinelφ with mid to late maturity (similar to Yitpiφ) and most suited to medium to higher rainfall areas. It has moderate (MS) CCN resistance, moderate (MR) resistance to all rusts and is MSS to yellow spot. Trojanφ has moderate boron tolerance and grain is large with low screenings and high test weight and acceptable black point resistance. Seed is available through Pacific Seeds.

Longreach Scout φ

Scoutφ (LPB05-1164) is an AH quality variety with mid-season maturity, derived from Yitpiφ. It has good resistance to stem and leaf rust and the WA stripe rust pathotypes but carries VPM and is rated MS to the WA+Yr17 pathotype in eastern Australia. Scoutφ is R to CCN and MRMS to powdery mildew but rated SVS to yellow leaf spot. Scoutφ has good physical grain quality and similar sprouting tolerance to Yitpiφ but slightly more susceptible to black point. Seed is available through Pacific Seeds (conditional Seed Sharing allowed).

Mace φ

Maceφ (RAC 1372) is derived from Wyalkatchemφ, but has an AH classification, taller plant height, is MR to stem rust, MR to leaf rust and is rated MRMS to CCN,YLS and *Pratylenchus thornei*. Although Maceφ has good resistance to the older WA stripe rust race, it is rated as SVS to the WA+ Yr17 stripe rust strain and if grown, must be carefully monitored and best avoided in districts prone to stripe rust unless a fungicide regime is in place. Maceφ has been widely tested since 2009 in NVT in SA and shows wide adaptation coupled with high yield potential and wheat on wheat application. Seed is available through AGT (conditional Seed Sharing allowed).

Shield φ

Shieldφ (RAC 1718) is an early to mid-season flowering, moderate yielding milling wheat with AH classification and acid soils tolerance. Shieldφ has resistance to CCN, good resistance to all rusts (stem rust – MR, stripe rust (WA-Yr17) – MR and leaf rust – R) and rated MSS to yellow spot. Shieldφ has good black point resistance (MRMS), moderate test weight and a low sprouting risk (MI). Seed is available from AGT.

Wallup φ

Wallupφ (VV4978-1) was released in 2011 for the Victorian Wimmera and other medium to higher rainfall regions. Wallupφ has AH quality combined with early to mid-season maturity, CCN resistance, acceptable stem, stripe and leaf rust resistance, moderate (MSS) levels of yellow leaf spot resistance and good black point resistance. It has useful resistance to root lesion nematodes, excellent straw strength and limited evaluation in NVT shows a moderate yield potential. Seed is available through AGT (conditional Seed Sharing allowed).

Table 2. Long Term summary of safety rating and potential % yield loss for selected bread wheat and durum varieties to various herbicides and tank mixes (Blyth and Mallala district trials)

Variety	AGT Katana⊕	Axe⊕	Catalina⊕	Correll⊕	Espada⊕	Estoc⊕	Gladius⊕	Hyperno⊕	Mace⊕	Saintly⊕	Scout⊕	Tjilkuri⊕	Rates (product/ha)	Crop stage at spraying
Years tested	**2009-2012**	**2008-2009**	**2007-2012**	**2006-2009**	**2009-2010**	**2009-2012**	**2006-2012**	**2009-2012**	**2009-2012**	**2009-2012**	**2009-2012**	**2009-2010**		
2,4-D Amine 625	✓(2)	**6** (1/2)	**N** (1/3)	**14** (1/4)	**N** (1/2)	✓(2)	**6-11** (2/4)	✓(2)	✓(2)	✓(2)	✓(2)	✓(2)	1.4L	2 node
Achieve®	✓(2)	**N** (1/2)	**N** (1/3)	**10** (1/4)	**7** (1/2)	✓(2)	**5** (1/4)	✓(2)	✓(2)	✓(2)	✓(2)	✓(2)	380g	3 leaf
Affinity®	✓(2)	✓(2)	✓(3)	✓(4)	✓(2)	✓(2)	✓(4)	**N** (2/4)	✓(2)	✓(2)	✓(2)	✓(2)	60g	3 leaf
Ally®	**6** (1/4)	**7** (1/2)	**N** (1/3)	**8-15** (3/4)	✓(2)	✓(2)	**9-18** (2/4)	✓(2)	✓(2)	✓(2)	✓(2)	✓(2)	7g	3 leaf
Axial®	**N** (1/4)	**5** (1/2)	✓(3)	✓(4)	✓(2)	**N** (1/4)	✓(4)	✓(2)	✓(2)	✓(2)	✓(2)	✓(2)	250mL	3 leaf
Banvel M®	-	**N** (2/2)	**N** (1/3)	**6** (1/4)	**7** (1/2)	-	**N** (2/4)	-	-	-	-	-	1.4L	5leaf
Boxer Gold®	✓(2)	✓(1)	✓(1)	✓(1)	✓(2)	✓(2)	**N** (1/1)	✓(2)	**N** (1/4)	✓(2)	✓(2)	✓(2)	2.5L	IBS
Bromoxynil/ MCPA	✓(2)	✓(2)	✓(3)	✓(4)	✓(2)	✓(2)	✓(4)	**5** (1/2)	**N** (1/4)	✓(2)	✓(2)	✓(2)	1.4L	3 leaf
Cadence®	✓(2)	**10** (1/2)	**6-10** (2/3)	**N** (1/4)	✓(2)	✓(2)	**9** (1/4)	**9** (1/2)	**N** (1/4)	✓(2)	✓(2)	✓(2)	200g	5 leaf
Conclude®	-	-	✓(3)	✓(2)	-	-	✓(3)	-	✓(1)	-	✓(3)	-	700mL	5 leaf
Crusader®	-	-	-	✓(1)	-	-	✓(2)	✓(1)	✓(1)	-	✓(2)	-	500mL	3 leaf
Diuron(500SC) /MCPA	✓(2)	**6** (1/1)	✓(2)	✓(3)	-	✓(2)	✓(3)	✓(2)	✓(2)	**6** (1/2)	✓(2)	✓(2)	500mL/350mL	3 leaf
Glean®	✓(2)	**9** (1/2)	✓(1)	**12** (1/2)	**6** (1/2)	**N** (2/4)	**7** (1/2)	**N** (1/4)	**N** (1/2)	**N** (1/3)	**N** (1/3)	✓(2)	20g	3 leaf
Hussar®	✓(2)	**10** (1/2)	**9** (1/3)	**12** (1/4)	✓(2)	✓(2)	**17-19** (2/4)	**N** (1/4)	✓(2)	**N** (1/3)	✓(2)	✓(2)	200g	3 leaf
Logran®	-	**N** (1/2)	✓(3)	✓(4)	**N** (1/2)	-	**5** (1/4)	-	-	-	-	-	35g	PSPE
LVE MCPA	-	✓(1)	✓(2)	✓(3)	-	-	**N** (1/3)	-	-	-	-	-	1.2L	5 leaf
Sakura®	-	-	✓(2)	✓(2)	-	-	✓(2)	-	-	-	✓(2)	-	118g	IBS
Tigrex®	✓(2)	✓(2)	✓(2)	**7** (1/4)	**7** (1/2)	✓(2)	**7** (1/4)	✓(2)	✓(2)	✓(2)	✓(2)	✓(2)	1L	5 leaf

X-y% (w/z)	Significant yield reductions at recommended rate in w years out of z years tested. eg 6-10 (2/4) is yield losses of 6 to 10% in 2 out of 4 years tested
x% (w/z)	Significant yield reduction at recommended rate in 1 trial only in z years of testing eg 8 (1/2) is 8% yield loss in 1 out of 2 years tested
N (w/z)	Narrow safety margin – yield loss at higher than recommended herbicide rate only w years of z years tested
✓(z)	no yield loss during z years of testing

Soft wheats

Longreach Impala $^{\phi}$

Impala$^{\phi}$ is an early to midseason soft biscuit (ASFT) wheat targeted to eastern Australia. Impala$^{\phi}$ has mid-season maturity, is susceptible to CCN, has good stem and stripe rust resistance, but is susceptible to leaf rust. Impala$^{\phi}$ produces large grain with improved test weight over Bowie and low screenings losses and is MRMS to black point. Seed is available through Pacific Seeds

Durum wheats

Tjilkuri $^{\phi}$

Tjilkuri$^{\phi}$ (WID801) has a similar maturity, adaptation and disease resistance profile to Tamaroi, but generally offers greater yields, like Hyperno$^{\phi}$ together with improved semolina colour. Tjilkuri$^{\phi}$ is eligible for APDR grade in SA and was released from the University of Adelaide in 2010 with seed available from the Durum Growers Association.

Yawa $^{\phi}$

Yawa$^{\phi}$ (WID803) was released from the University of Adelaide with seed available from the Durum Growers Association. Yawa$^{\phi}$ has a similar maturity, adaptation and disease resistance profile to Tamaroi, but offers very high yields, albeit with generally small grain size and high screening potential under stress conditions. Yawa$^{\phi}$ has excellent semolina colour and is eligible for APDR grade in SA.

WID802 $^{\phi}$

WID802$^{\phi}$ has just been released from the University of Adelaide with seed available from the Durum Growers Association. WID802$^{\phi}$ is targeted for the SE of SA (Tatiara districts) and has a similar maturity, adaptation and disease resistance profile to Tamaroi, but offers high yields, albeit with sometimes small grain size. WID802$^{\phi}$ is eligible for APDR grade in SA.

Wheat variety tolerance to herbicide

(Project Officer: Michael Zerner, SARDI, Waite)

Experiments investigating the tolerance of crop varieties to herbicides are conducted by State agencies throughout Australia, supported by funding from GRDC. Details and results of the studies can be found in State publications, and also on the NVT web site, www.nvtonline.com.au.

Table 2 summarises this work in SA within trials conducted in the Hart/Kybunga area since 1993. Within these experiments, a wide range of herbicides and tank mixes are applied pre and post sowing (crop dependent), at label recommended and twice recommended rates across each variety, under *weed free* conditions. The treatment rates provided an estimate of the varietal tolerance and safety margin likely through any differences in varietal response between the untreated control and the two rates applied. Preliminary results from evaluation of some newer chemistries e.g. Boxer Gold® and Sakura® against newer varieties can be found at www.nvtonline.com.au. Likewise with some of the more recently released varieties such as Cobra$^{\phi}$, Corack$^{\phi}$, Emu Rock$^{\phi}$ and Phantom$^{\phi}$. Of these varieties, in early preliminary testing, Emu Rock$^{\phi}$ has shown to be more sensitive to Sakura® than other varieties when applied at above label rates.

Comments and summary tables on varietal tolerance are generally based on data gained from two or more season's experimental results, as year to year variation can be significant.

Dennis and Robert Dall and Richard Konzag are gratefully acknowledged for providing land for these experiments together with the SARDI Clare New Variety Agronomy team for their help in trial management.

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Notes

Controlling herbicide resistant radish with herbicides in the Northern Agricultural Region (NAR) of WA with a two spray strategy

Grant Thompson,
Crop Circle Consulting

Keywords

wild radish, herbicide resistance

Take home messages

- **Herbicide resistant wild radish can be controlled well by a range of herbicides if applied early when weeds are small.**
- **A two spray strategy has proven to be very effective at controlling wild radish, particularly when the first spray is effective and is done as early as possible on small weeds.**
- **Know your resistance status and your best mode of action for success.**

Introduction

The threat of multiple herbicide group resistant radish and 'stacked' resistant radish is a great concern to growers and crop protection professionals throughout the Northern Agricultural Region (NAR) of Western Australia's grain belt. For many years, the widespread use of effective and low cost herbicide mixes in cereals, based mainly on group I and B chemistry, has led to an alarming level of resistance in wild radish. More expensive broadleaf herbicides have also been used at below label rates for many years. Coupled with often poor application conditions and water volumes, this has created significantly enhanced selection pressure. In many cases these radish populations have also had significant exposure to group F and C herbicide groups in both cereal and broadleaf crops. Surviving plants to these herbicide groups over many seasons have shared resistance genetics and have created multiple herbicide group resistance within populations and individual plants, resistant to several modes of action.

Also of significant concern to the industry is the repetitive use of two new herbicides (Precept and Velocity) that contain the relatively new active pyrasulfotole (Group H). In many cases, two applications of pyrasulfotole are being applied in cereal crops to achieve acceptable wild radish control. Given the overuse and abuse of older modes of action, the industry as a whole needs to be very conscious of using this new active carefully in order to prolong its life within our farming system.

This paper demonstrates clear options for growers based on a second year of work conducted by the Northern Agricultural Region GRDC RCSN Initiative. In 2012, work conducted by Planfarm and AHRI showed that many two spray strategies were successful in controlling multiple herbicide group resistant radish through timely application and good water volumes with robust herbicide packages. The second year of work (2013), conducted at different locations on different populations in the NAR, also demonstrates that the best practice management of multiple herbicide group resistant radish revolves around early spraying followed by a quick and timely second spray with robust herbicide rates.

Objectives

The RCSN group clearly identified several objectives for this project:

1. Provide a Best Practice Management Guide to growers dealing with multiple herbicide group resistant radish, supported by thorough herbicide research.
2. Test or support the projects previous findings that not only is herbicide choice important, but timing, application volumes and weed size is also important in achieving weed control.
3. Provide opportunities for extension of these messages with field days for growers and advisers to visually inspect the trial work.

Methodology

Three large scale experiments were conducted in 2013.

1. Trial 1 (HUSBANDS) was at Paul Husbands's farm in Northampton. This site was resistance tested by Elders and Plant Science Consulting and found to have concerning levels of resistance to four herbicide groups.
2. Trial two (BROAD) was at Ian Broad's farm at Mingenew. This site was known to several agronomists in the region as having a very hard to kill radish population.
3. Trial 3 (JERICHO) was at Paul Messina's farm at South Yuna. This site was an application by timing trial on a very high density population. A large scale herbicide resistance screen was also conducted at the property.

Trial 1 and 2: The BROAD and HUSBANDS trial sites were sprayed as follows:

First spray treatments at the two leaf stage of the wheat crop – applied with a TEEJET AIXR11002 nozzle at 60L/Ha, 600KPA and 12km/hr.

1. Nil
2. 1500ml Bromicide 200
3. 1000ml Jaguar
4. 670ml Velocity + 1% Hasten

The second spray treatments were applied at five leaf stage – applied with an AGROTOP AIRMIX 110 01 nozzle at two bar at 98L/Ha at 4km/hr. The second treatments were applied at right angles across the first spray treatments in what is known as a criss-cross trial pattern.

Table 1. Layout of first spray treatments applied at two leaf stage of the wheat crop

	48m	buffer 6m	48m	buffer 6m	48m
9m	nil		Velocity		Jaguar
9m	bromicide 200 @ 1.5L		nil		Velocity
9m	Jaguar @1.0L		Brom 200		nil
9m	Velocity @670ml		jaguar		Brom 200
	plots 1-14		plots 15 - 28		plots 29 - 52

Table 2. Second spray treatments applied at five leaf stage of the crop, over the top of the two leaf stage treatments

Trt	Herbicide Treatment and Adjuvant	Rate/Ha or % volume
1	nil	0
2	Velocity + Uptake	800ml + 0.5%
3	Flight 720 EC	720ml
4	Precept 150 + metribuzin + amsul	1500ml + 60g +1%
5	Estercide Xtra 680 + Logran + Uptake	800ml + 10g + 0.5%
6	Tigrex + Ecopar	1000ml + 200ml
7	Precept 150 + Ecopar + Amsul	1000ml + 200ml + 1%
8	Jaguar + Agritone 570 LVE	500ml + 440ml
9	Jaguar + Estercide Xtra 680	1000ml + 800ml
10	Precept 150 + Bromicide MA + Uptake	1500ml + 1000ml + 0.5%
11	Velocity + Jaguar + Estercide Xtra 680	670ml + 500ml + 800ml + 0.5%
12	FMZ 1209 + Bromicide MA	250ml + 750ml
13	Velocity + X -Pand + Uptake	670ml + 125g + 0.5%

This layout then achieved a trial that had 52 (4 x 13) treatments of 9m x 2m area, replicated 3 times.

The water sensitive paper strips placed in the crop drill row and between the drill rows at both sites (below) demonstrate excellent application coverage onto weeds and penetration through the crop at the HUSBANDS (L) and BROAD (R) sites.

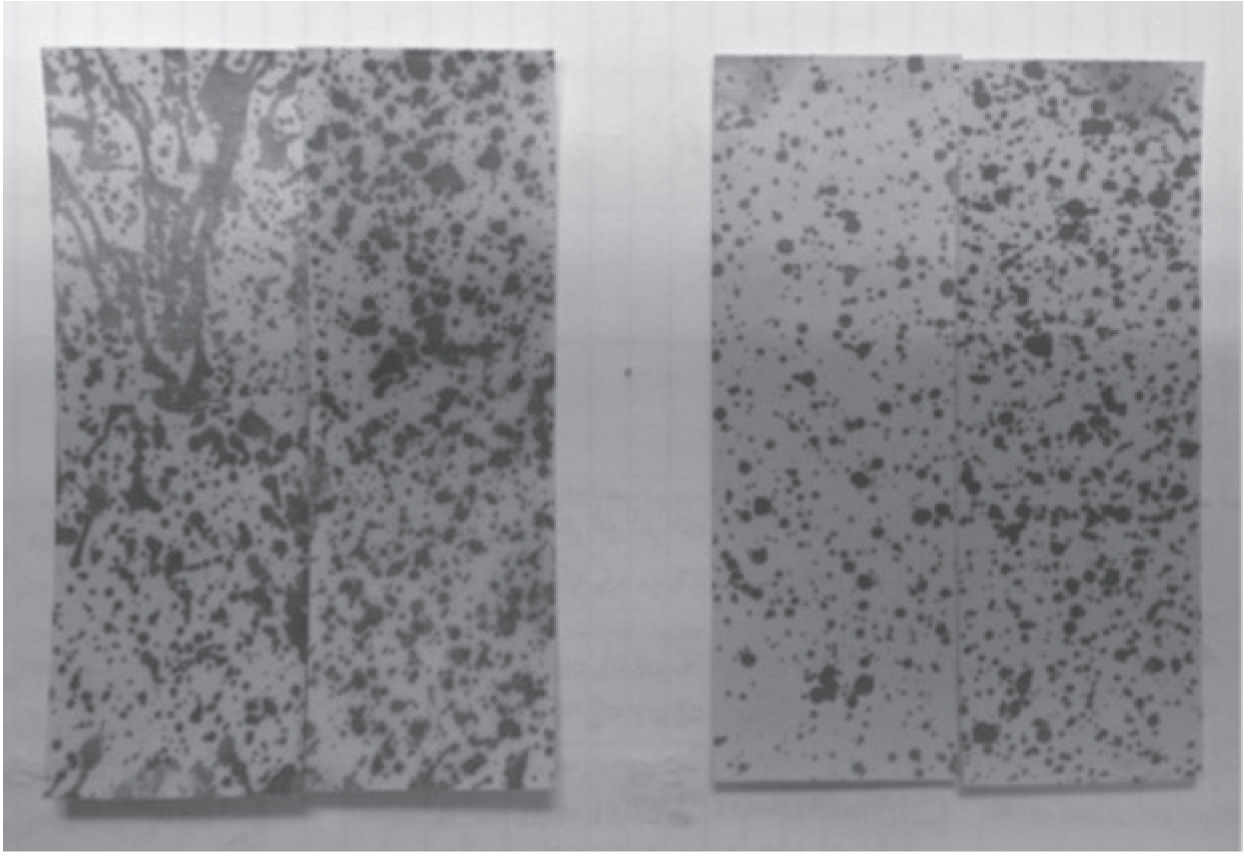

Figure 1. Application coverage at BROAD and HUSBANDS sites.

Table 3. Herbicide treatments applied at two or five leaf stage of the crop

Trt	Herbicide	Rate	Herbicide/ Adjuvant	Rate	Adjuvant	Rate	Growth Stage
1	NIL						
2	Jaguar	750 ml/ha					Z12
3	Velocity	500 ml/ha	Hasten	1 %			Z12
4	Jaguar	800 ml/ha	MCPA LVE 570	440 ml/ha			Z15
5	Velocity	670 ml/ha	MCPA LVE 570	440 ml/ha	Hasten	1%	Z15
6	Logran	10 g/ha	MCPA LVE 570	440 ml/ha	Hasten	1%	Z15
7	Aptitude*	200 ml/ha	MCPA Amine 500	500ml/ha			Z15

**Registration pending*

The JERICHO trial was a two time of application trial, using common and new herbicide mixtures applied at either two leaf or five leaf stage of the crop, on a high density radish site.

These spray treatments were applied with an AGROTOP AIRMIX 110 01 nozzle at two bar at 98L/Ha at 4km/hr. Weeds were cotyledon to two leaf at Z12, or 4-6 leaf and up to 20cm at Z15.

Resistance Profiles of the trial site populations

HUSBANDS trail site: Glass house resistance tests by Plant Science Consulting / Belinda Eastough (Elders):

- 100% survival to 40g Logran (B)
- 45% survival to 2L Simazine (C)
- 0% survival with 1400ml Bromoxynil (C)
- 85% survival to 200ml Brodal (F)
- 0% survival with 500ml Velocity (H,C)
- 60% survival to 650ml 2,4-D Ester (I)

JERICHO trial site: In field resistance screen by Landmark R and D / Robert Alderman and Grant Thompson

- 81% survival to 30g Logran (B)
- 43% survival to 2L Atrazine (C)
- 57% survival to 200ml Brodal (F) 40% survival to 400ml Brodal
- 15% survival to 800ml 2,4-D Ester (I), 12% survival to 1600ml 2,4-D Ester.
- 62% survival to 500ml Intervix (B)
- 8% survival with 500ml Velocity (H & C)

Observations and results

The data in Table 4 (HUSBANDS) clearly demonstrates the success of the two spray strategy when Bromicide 200, Jaguar and Velocity were used at the early two leaf timing. When no late spray was used to clean up survivors, Velocity was the most reliable early spray, as indicated by 97% and 100% weed control in the two nil late spray treatments (Trt 1&14). At 10 days after Treatment 2 (T2) was applied, Velocity at 800ml, Tigrex + Ecopar and Precept + Ecopar gave significantly higher crop phytotoxicity results ($p<0.05$) than the other treatments.

When there was no early spray applied, the later five leaf stage sprays (T2) were put under a great deal of pressure. With approximately 200 radish plants/m2, there was shading of radish by other radish in many plots. If the treatment did not contain a systemic mode of action, then some of the contact only modes of action were put under more pressure. This is demonstrated by the one late spray of 800ml of Velocity at five leaf stage achieving 93% control, but an early spray at the two leaf stage on much smaller weeds achieved 100% control. This trial also shows that most treatments recommended by the RCSN group were successful in controlling this population, even with the very high levels of resistance present in the test results.

Another point of interest is that a second flush of radish occurred after a mid-season rain in July. This germination died as a result of another short dry spell and a significant amount of competition from a crop that had reached Z39 and was using all available soil moisture.

The crop effects of Flight EC (Trt 3) and Precept + metribuzin (Trt 4) were still clearly evident at 32 days after application (DAA). Radish in the Estercide + Logran treatment trial sites took a very long time to die, with many plants showing some level of twisting and distortion but no plant death at 32DAA.

By 32DAA, the leaf burning caused by the Precept + Ecopar and Tigrex + Ecopar treatments was less evident. These burnt older leaves had almost completely senesced.   The Jaguar + MCPA treatment had many survivors growing through the herbicide effects, with survivors exhibiting the typical dark green sheen associated with group F tolerance in radish. The more robust treatment of the higher rate of Jaguar + 24D ester had very few surviving plants at this time.

The Precept + Bromicide MA treatment was very clean at 32 DAA and there were no surviving plants or skeletons of old plants. There were also no crop symptoms visible. The Velocity + Jaguar + Estercide treatment was also extremely clean, but the treatment did noticeably thin out the crop canopy; plants were less leafy and there were less tillers per plant.

The FMZ 1209 treatment did have some survivors when used as a stand-alone single late spray option. This is a new and experimental product,

Table 4. Crop Phytotoxicity (%) 11 Days after application of Treatment 2 and efficacy (% plant death) at 11 and 105 Days after Treatment 2 at HUSBANDS

			no early T1 spray			T1 1500ml Brom 200 z12			T1 1000ml Jaguar z12			T1 670ml Velocity z12		
			crop phyto	efficacy	efficacy	crop phyto	efficacy	efficacy	crop phyto	efficacy	efficacy	crop phyto	efficacy	efficacy
No.	T2 Treatments	Rate/Ha or % Volume	10DAA (%)	10DAA (%)	64DAA (%)	10DAA (%)	10DAA (%)	64DAA (%)	10DAA (%)	10DAA (%)	64DAA (%)	10DAA (%)	10DAA (%)	64DAA (%)
1	Nil	0	**20**	0	0	20	93	73	20	94	90	23	96	**100**
2	Velocity + Uptake	800ml + 0.5%	**23**	54	93	23	**100**	**100**	25	**100**	**100**	25	**100**	**100**
3	Flight 720EC	720ml	15	63	**100**	13	98	**100**	13	**100**	**100**	13	**100**	**100**
4	Precept 150 + metribuzin + amsul	1500ml + 60g	7	68	**100**	13	**100**	**100**	10	**100**	**100**	7	**100**	**100**
5	Estercide Xtra 680 + Logram + Uptake	800ml + 10g + 0.5%	7	17	**100**	7	93	**100**	4	98	**100**	7	99	**100**
6	Tigrex + Ecopar	1000ml + 200ml	**23**	69	**100**	22	**100**	**100**	20	**100**	**100**	23	**100**	**100**
7	Precept 150 + Ecioar + Amsul	1000ml + 200ml + 1%	18	66	98	18	**100**	**100**	22	**100**	**100**	20	**100**	**100**
8	Jaguar + Agritone 570 LVE	500ml + 440ml	8	31	91	8	97	**100**	7	**100**	**100**	8	**100**	93
9	Jaguar + Estercide Xtra 680	1000ml + 800ml	10	52	**100**	10	99	**100**	10	97	**100**	8	**100**	**100**
10	Precept 150 + Bromicide MA + Uptake	1500ml + 1000ml + 0.5%	7	82	**100**	10	99	**100**	10	**100**	**100**	8	**100**	**100**
11	Velocity + Jaguar + Estercide Xtra 680	670ml + 500ml + 800ml + 0.5%	13	90	**100**	13	**100**	**100**	12	**100**	**100**	12	**100**	**100**
12	FMZ 1209 + Bromicide MA	250ml + 750ml	12	28	77	15	98	**100**	12	**100**	**100**	12	**100**	**100**
13	Velocity + X-Pand + Uptake	670ml + 125g + 0.5%	15	60	**100**	15	**100**	100	15	**100**	**100**	15	**100**	**100**
14	nil	0	0	0	0	0	88	67	0	81	75	1	99	97
		LSD 0.01	27	62	166	28	7	172	27	7	174	22	2	7
		LSD 0.05	20	46	123	20	5	127	20	5	129	16	1	5
		CV	94	56	88	91	3	79	92	3	79	74	1	3

and has perhaps been used at a rate too low in this situation. The addition of 125g X-Pand to Velocity, did not affect efficacy by 10DAA, and achieved 100% control by 64DAA.

Table 5 shows that a yield advantage of 4-500kg/ha was consistently achieved if an early two leaf spray (T1) of either Bromicide 200, Jaguar or Velocity is followed up with any number of the five leaf stage spray (T2) options. Yields ranged from 2.63 - 3.06t/ha when only one late spray was applied. When the two spray strategy was implemented, yields ranged from 3.1-3.64t/ha throughout the trial. In one case, the combination of an early Bromicide 200 spray at T1 took the yield of treatment 12 (FMZ + Brom MA at five leaf stage) from 2.63t/ha to 3.64t/ha, a yield increase of 1.01t/ha. Given a radish density of 200 plants/m2, these results demonstrate the importance of spraying early for improved efficacy and yield benefits.

Table 5. Crop yield (t/ha) and yield (%) compared to nil of all treatments at the HUSBANDS site

			No early T1 spray		T1 1500ml Brom 200 z12		T1 1000ml Jaguar z12		T1 670ml Velocity z12	
No.	**T2 Treatments**	**Rate/Ha or% Volume**	**YIELD %**	**YIELD t/ha**	**YIELD %**	**YIELD t/ha**	**YIELD %**	**YIELD t/ha**	**YIELD %**	**YIELD t/ha**
1	Nil	0	100	2.88	100	3.12	100	3.27	100	3.17
2	Velocity + Uptake	800ml + 0.5%	96	2.76	103	3.20	101	3.31	104	3.25
3	Flight 720EC	720ml	95	2.73	103	3.22	103	3.37	104	3.29
4	Precept 150 + metribuzin + amsul	1500ml + 60g	97	2.80	101	3.17	**106**	3.47	101	3.19
5	Estercide Xtra 680 + Logram + Uptake	800ml + 10g + 0.5%	91	2.63	98	3.05	103	3.37	102	3.24
6	Tigrex + Ecopar	1000ml + 200ml	94	2.71	107	3.34	100	3.26	104	3.31
7	Precept 150 + Ecioar + Amsul	1000ml + 200ml + 1%	93	2.69	**109**	3.41	97	3.16	105	3.33
8	Jaguar + Agritone 570 LVE	500ml + 440ml	91	2.62	105	3.29	**108**	3.53	98	3.11
9	Jaguar + Estercide Xtra 680	1000ml + 800ml	98	2.81	**112**	3.5	102	3.35	105	3.32
10	Precept 150 + Bromicide MA + Uptake	1500ml + 1000ml + 0.5%	95	2.73	**111**	3.48	101	3.32	**108**	3.43
11	Velocity + Jaguar + Estercide Xtra 680	670ml + 500ml + 800ml + 0.5%	95	2.74	**110**	3.43	104	3.39	101	3.19
12	FMZ 1209 + Bromicide MA	250ml + 750ml	91	2.63	**117**	3.64	99	3.23	101	3.21
13	Velocity + X-Pand + Uptake	670ml + 125g + 0.5%	106	3.06	105	3.29	**107**	3.50	105	3.33
14	nil	0	66	1.91	99	3.10	98	3.21	**110**	3.47
		LSD 0.01	21	0.6	11	0.33	6	0.21	9	0.30
		LSD 0.05	15	0.44	8	0.25	5	0.15	7	0.22
		CV	3.39	9.76	1.42	4.44	0.84	2.80	1.26	3.98

n.b. numbers in bold are significantly different (P<0.05) from Trt 1

The return on investment from these early spray treatments is substantial. Including application costs, these early two leaf spray treatments cost, $19 - $29 per hectare. Their application results in an increase in net profit of approximately $90-$130/ha given the consistent yield improvements of between 4-500kg/ha of wheat ($290/t). In the case of Treatment 12, an increase of $260/ha grain returns was achieved by using 1.5L Bromicide 200 at T1 as well as the later T2 spray.

The data in Table 6 (BROADS) demonstrates the clear advantage of spraying first with either Jaguar or Velocity at the two leaf stage of the wheat crop when weeds are small. All treatments achieved 100% weed control when sprayed with the early two leaf spray of either Jaguar or Velocity. The Bromicide 200 early spray treatment also showed clear benefits in final weed control, but was not quite as reliable as the Jaguar and Velocity early treatments, with 3 of the later treatments having some survivors. With no early spray, many of the T2 (five leaf stage) treatments had surviving plants at 105 DAA. Conditions at the time of application were not ideal, as the region was suffering from an extended heat and moisture stress period for 6 weeks. This site also had a pre-emergent application of Diuron applied by the host farmer, which did contribute to some crop phytotoxicity and radish control, as indicated by the crop phytotoxicity and weed control in the nil plots&. The radish density and uniformity at this site was uneven, which also contributed to the variable control achieved in the no early spray treatments.

Figure 2. Radish at 2nd spray timing at HUSBANDS.

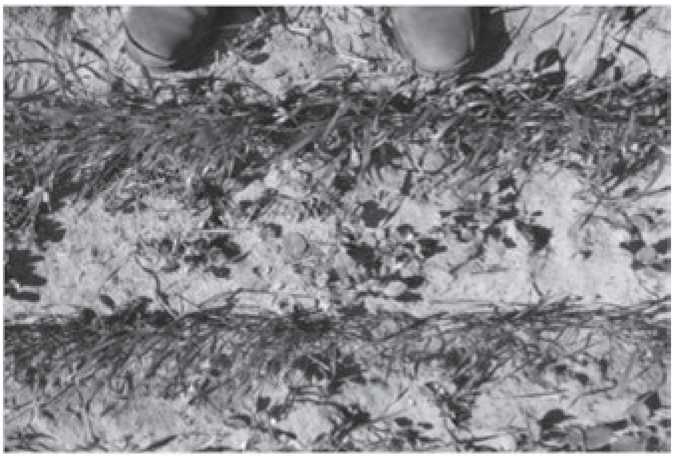

Figure 3. Radish at 1st spray timing at JERICHO.

Figure 4. Crop phytotoxicity from Ecopar (Treatments 6 and 7).

Figure 5. Growers and advisers visit HUSBANDS site.

Table 6. Crop Phytotoxicity (%) 11 Days after Application of Treatment 2 and Efficacy (% plant death) at 11 and 105 Days after Treatment 2 at BROADS.

			no early T1 spray			T1 1500ml Brom 200 z12			T1 1000ml Jaguar z12			T1 670ml Velocity z12		
			crop phyto	efficacy	efficacy	crop phyto	efficacy	efficacy	crop phyto	efficacy	efficacy	crop phyto	efficacy	efficacy
No.	**T2 Treatments**	**Rate/Ha or % Volume**	**10DAA (%)**	**10DAA (%)**	**64DAA (%)**	**10DAA (%)**	**10DAA (%)**	**64DAA (%)**	**10DAA (%)**	**10DAA (%)**	**64DAA (%)**	**10DAA (%)**	**10DAA (%)**	**64DAA (%)**
1	Nil	0	23	63	96&	20	**100**	**100**	20	**100**	**100**	22	**100**	**100**
2	Velocity + Uptake	800ml + 0.5%	27	43	77	28	1**00**	**100**	27	**100**	**100**	27	**100**	**100**
3	Flight 720EC	720ml	17	30	80	13	98	**100**	13	**100**	**100**	10	**100**	**100**
4	Precept 150 + metribuzin + amsul	1500ml + 60g	12	42	97	17	**100**	**100**	18	97	**100**	15	**100**	**100**
5	Estercide Xtra 680 + Logram + Uptake	800ml + 10g + 0.5%	15	23	90	10	98	**100**	12	88	**100**	15	**100**	**100**
6	Tigrex + Ecopar	1000ml + 200ml	23	77	97	22	93	**100**	20	**100**	**100**	22	**100**	**100**
7	Precept 150 + Ecioar + Amsul	1000ml + 200ml + 1%	23	67	97	23	98	**100**	13	**100**	**100**	18	**100**	**100**
8	Jaguar + Agritone 570 LVE	500ml + 440ml	13	37	93	8	83	**100**	10	97	**100**	15	**100**	**100**
9	Jaguar + Estercide Xtra 680	1000ml + 800ml	17	47	93	15	80	77	8	93	**100**	17	**100**	**100**
10	Precept 150 + Bromicide MA + Uptake	1500ml + 1000ml + 0.5%	10	38	90	15	93	**100**	10	**100**	100	13	**100**	**100**
11	Velocity + Jaguar + Estercide Xtra 680	670ml + 500ml + 800ml + 0.5%	15	35	87	17	**100**	97	17	**100**	**100**	18	**100**	**100**
12	FMZ 1209 + Bromicide MA	250ml + 750ml	20	57	87	10	77	87	17	**100**	**100**	17	**100**	**100**
13	Velocity + X-Pand + Uptake	670ml + 125g + 0.5%	20	67	93	17	**100**	**100**	18	97	**100**	20	**100**	**100**
		LSD 0.01	27	62	166	28	7	172	27	7	174	22	2	7
		LSD 0.05	20	46	123	20	5	127	20	5	129	16	1	5
		CV	94	56	88	91	3	79	92	3	79	74	1	3

n.b. & see comments above; numbers in bold are significantly different (P<0.05) from Trt 1

Table 7 (JERICHO) shows that there is a significant yield improvement of between 22-36% by spraying radish at this trial site. More importantly, there is an improvement in efficacy when wild radish is sprayed early before shading occurs. Even when MCPA (grp I), a systemic herbicide, is added to Jaguar at the later five leaf spray timing, radish control declined compared to the early Jaguar spray at two leaf stage. Velocity achieved the highest level of control (100%) at two leaf stage, but when MCPA was added and sprayed at five leaf stage, the treatment still achieved 100% control and did not suffer a reduction in efficacy like the Jaguar + MCPA treatment. The Velocity based treatments (Trt 3 and 5) were also 10-13% higher yielding than the Jaguar based treatments (Trt 2 and 4). The data clearly shows that herbicide choice and time of application are both important factors in achieving the best weed kill and highest grain yield.

The data also clearly shows that knowledge of the herbicide resistance status is important. Treatment 6 (Group I and B) and Treatment 7 (Groups I, C, G) clearly underperformed, which is not unexpected given the in-field resistance screen results mentioned earlier.

Discussion

The trial work conducted here fully supports the findings from the 1st year of the project (2012), that early spraying of small weeds followed by a timely second follow up spray, with a robust herbicide rate, is highly effective at controlling resistant radish populations. The 2013 data clearly shows that there are other options for the two spray strategy than the two consecutive doses of pyrasulfotole (group H). However, the data does show that herbicide mixes containing pyrasulfotole are highly effective

Table 7. Efficacy 76DAA (%) and crop yield (t/ha) of treatments at two different times of application at the JERICHO site.

Trt	Treatments			Efficacy 76DAA %	Yield as % of untreated	Yield kg/ha
1	Nil			0	100%	1400
2	Jaguar	750 ml/ha	Z12	96	**126%**	1768
3	Velocity + Hasten	500ml/ha 1%	Z12	**100**	**136%**	1911
4	Jaguar + MCPA LVE 570	800ml/ha 440ml/ha	Z15	67	**123%**	1722
5	Velocity + MCPA LVE 570 + Hasten	670ml/ha 440ml/ha Hasten 1%	Z15	**100**	**136%**	1905
6	Logran + MCPA LVE 570 + Hasten	10g/ha 440ml/ha Hasten 1%	Z15	43	**122%**	1701
7	Aptitude* + MCPA Amine 500	200ml/ha 500ml/ha	Z15	48	**127%**	1774
			LSD 0.01	120	20.00	280.42
			LSD 0.05	85	14.00	200.01
			CV	74	0.00	6.46

n.b. Radish pod contamination of the nil sample was significant. Yield of wheat grain had to be estimated based on proportion of radish pod to wheat grain; numbers in bold are significantly different ($P<0.05$) from Trt 1 and reliable in many conditions. The trial also shows that there are significant improvements in efficacy and grain yield by implementing a two spray strategy when radish density is high. This season had a significant dry spell for most of June, which may have emphasized the grain yield losses from late weed control. Yield gains of up to 1t/ha were achieved at the HUSBANDS site from doing the two spray strategy instead of only one.

The focus of the RCSN group was to develop alternative control options to prevent the overuse and abuse of the group H active pyrasulfotole. This trial data does show that there are several reliable alternatives to the two group H products. However, in identifying alternative options, we encounter a new problem. Many of the alternative non- group H options identified at the HUSBANDS and BROAD sites contained Bromoxynil. In our attempts to preserve and use group H wisely, we must also ensure we do not inadvertently abuse and overuse group C chemistry, specifically Bromoxynil.

The addition of 200ml Ecopar (Pyraflufen-ethyl – Grp G) to Tigrex and Precept (Trts 6 & 7) achieved consistently high radish control. Although resulting in high levels of crop phytotoxicity early, these treatments had recovered by 32DAA. However, the top two wheat leaves at the time of application had completely senesced and although there was not a significant yield loss in this dry season, yield losses could occur in a better season where more crop biomass leads to greater grain yields. If growers and advisers are willing to accept this crop effect then these treatments can also become a very handy alternative.

The data from the HUSBANDS trial also presents a few questions rather than just providing answers. The resistance testing from this site identified a poor level of activity from group B, F and I, yet the Treatment 5 (Estercide and Logran (I & B)) eventually achieved 100% control of radish when used as a stand-alone or after an early spray. It was noted that this treatment took a very long time to achieve a complete kill of wild radish, however this does cast some doubt over the value of herbicide resistance testing as a sole determinant of a population's resistance status in a whole paddock. Actual in-paddock herbicide mode of action and rate response screens are a much more reliable method of determining a resistance status of a population.

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Notes

To guess, to probe or to model soil water– an agronomist's dilemma

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Keywords

soil moisture probes, APSIM simulations, Yield Prophet®, crop water use, crop yield, decision making

Take home messages

- **Soil moisture probes provide easily understood outputs of soil water**
- **Yield Prophet®, using APSIM modelling, simulates soil water, crop water use and N use on a daily basis and provides a risk assessment, through probability, of achieving a target yield**
- **If all you want is information on soil water then using a probe will be adequate to your needs. However, if you are after an integrated approach to making strategic and tactical decisions on the least frost and heat shock sowing date for your choice of variety, crop water and N use and the impact of seasonal forecasts on likely production then modelling is the only way to go.**

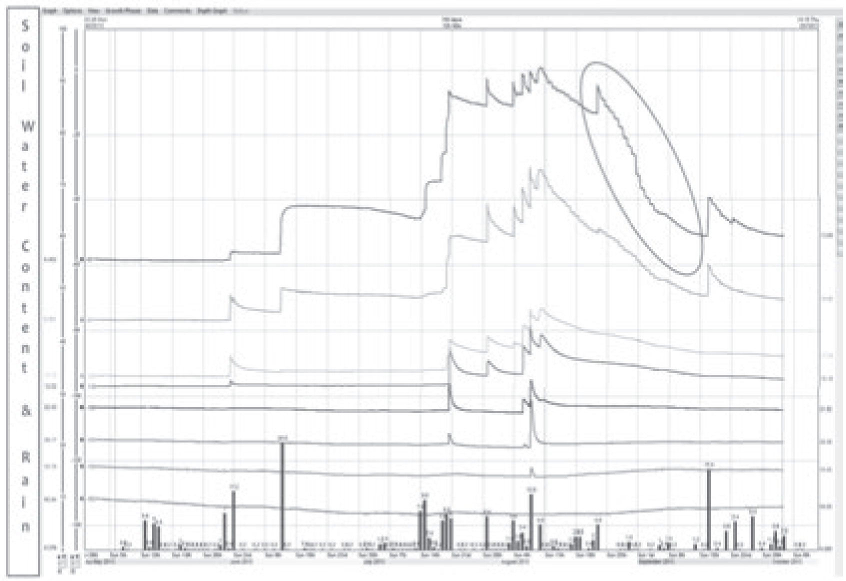
Aim

(i) to compare soil water information provided by soil moisture probes vs. modelled outcomes from APSIM (Yield Prophet®)

(ii) to evaluate soil moisture probes vs. modelled outcomes for day to day paddock management decisions

Comparing soil water information presented by probes and Yield Prophet®

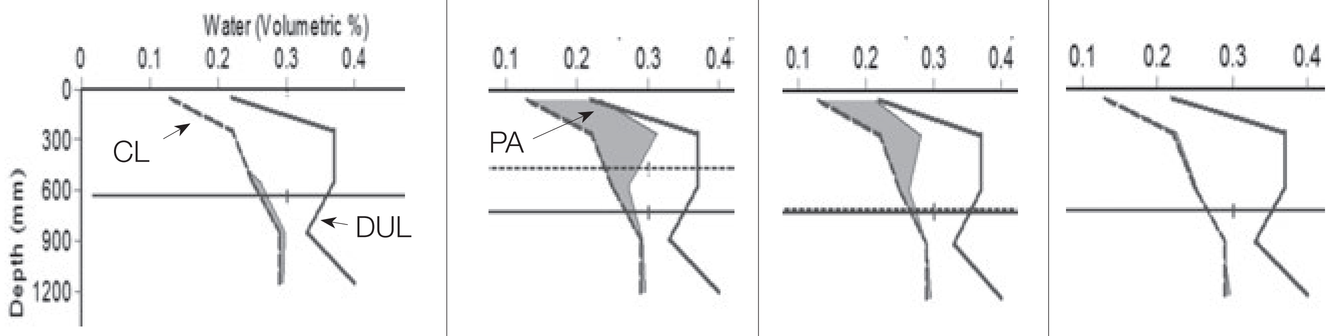
The type of information provided by soil moisture probes and Yield Prophet® are detailed in Figures 1 and 2, including comments on each method.



Comments:

- Shows total soil water and increase in soil water following rain
- Dry period during Aug-Sep depleted most of the available stored water (period highlighted on the graph)
- Shows limit to plant water use at 60cm (rooting depth)
- Estimate of Crop Lower Limit (CLL) at the end of this cropping season (after a long dry spell)
- Note Drained Upper Limit (DUL) was probably not achieved
- Uses a generic calibration for calculating volumetric soil water

Figure 1. Typical soil moisture probe data representation for a wheat crop – May to October 2013. Lines are soil moisture content (mm) at 8 depths in the profile (shallowest 30cm, deepest 100cm). Bars are rainfall (mm).



3 May, 2013 (sowing date for Scout[D] wheat) PAW=8mm Evap+Water use=0.1mm/day	21 July, 2013 PAW=44mm Evap+Water use = 1.3mm/day	26 Aug, 2013 PAW=44mm Evap+Water use = 2.2mm/day	3 Nov, 2013 PAW=6mm Evap+Water use = 0.1mm/day

Comments:

- CLL (Crop Lower Limit) and DUL (Drained Upper Limit) from soil characterisation (users have access to a large Australia wide data base of characterised soils)
- PAW (Plant Available Water) highlighted on the graph and listed as an output in mm
- Daily water balance as simulated from the time of soil sampling (pre-sowing)
- Daily water use provided
- Water stress exhibited by the crop expressed in another graph

Figure 2. APSIM modelled Plant Available Water (PAW) as represented by Yield Prophet® for a wheat crop in 2013.

Interpretation of soil water information provided by probes vs model (Yield Prophet®)

The pros and cons of using soil moisture probes or Yield Prophet® for interpreting soil water information are outlined in Table 1.

Table 1. Pros and cons of soil moisture probes and simulated outcomes from Yield Prophet®

Soil moisture probes		Yield Prophet®	
Pros	**Cons**	**Pros**	**Cons**
• Continuous reading, and can be used to set starting water in models (if calibrated). • Easy to interpret visual output of changes in soil water content. • Depth of water extraction can be interpreted from the graph (rooting depth). • Good training tool for farmers to understand what happens to soil water during the year (including soil water loss from summer weeds, crop water use etc.). • Provides information on infiltration and through-flow of water in the subsoil (water loss beyond the root zone).	• Signal must be calibrated to provide volumetric soil water content. • Only measures a small area around the probe (up to 10cm, with 95% of the signal only 4cm from the probe). • The signal is influenced by the slurry used to embed the probe (air gaps). • Poor performance in cracking clays and stony soils (air gaps). • PAW can only be calculated if DUL and CLL are known (which can be done using a probe but only following a very wet period and a long dry period during spring. • Need training in interpreting graphs and associated data.	• When calibrated, APSIM modelling of soil water is an accurate representation of the amount of water available to the crop at any stage during the season. • Includes detail on daily crop water and nitrogen use, rooting depth and level of water and nitrogen stress exhibited by the crop. • Planning tool for soil water and nitrogen use and calculates a projected yield (probability based). • Provides crop variety phenology information specific to location assisting in crop management decisions. • Capacity to generate a range of 'what if' scenarios to aid learning in crop production. • An excellent agronomic training tool for farmers and advisers.	• Model needs to use a characterised soil from the extensive APSOIL database or have the soil characterised to accurately calculate Plant Available Water-holding Capacity (PAWC). • Need to take soil water and N measurements prior to sowing (to initialise the model). • Users need training in interpreting graphs and associated information on crop growth, N and water use, probability functions, etc.

Costs

Capacitance type probe + data logger: $5000+; annual maintenance + mobile network connection: $350/yr.

Yield Prophet®: $170/paddock.

Note both methods require soil sampling + analysis (available N and soil water): approx. cost $350/paddock.

Soil water is only part of the story – what about N?

The amount of soil water available to a crop is clearly of critical importance when assessing the risk of dryland crops being able to complete their growth cycle and in particular to fill grain at the end of the season. However, water is only part of the story, the other critical factor is how much N is available to the crop and required by the crop to fulfil its potential. Soil moisture probes do not provide information on soil/crop N status, and therefore, some kind of N budget is still required when deciding on whether the crop needs additional N in relation to how much water the crop has available to it. APSIM simulations, through Yield Prophet® provide information for a crop's daily water and N use, how much water and N are still in the soil, level of water and N stress exhibited by the crop at any stage during the season, and through probability functions, how much water and N is required to achieve a particular yield outcome.

What else?

Yield Prophet® output goes beyond assessment of soil water and nitrogen. Users have the ability to explore and compare a range of interacting factors that influence crop production, such as evaluating the least frost and heat shock risk of different varieties. The ability to simulate crop production by changing one or more factors provides the user with a learning platform that improves their understanding of crop production in a way that probes cannot.

So why the interest in soil probes?

Soil probes provide no additional information to that generated in the Yield Prophet® model, and are nearly 30 times the cost. Model supporters are challenged by the interest in probe use by farmers and some advisers when models have been doing the same for longer and for a fraction of the cost. Why are probes so popular?

Using Rogers' adoption theory, a comparison of the uptake of different technologies can be made. Rogers describes five key criteria of new technology adoption. These are:

1. Relative advantage,
2. simplicity/complexity,
3. trialability,
4. observability; and
5. compatibility.

A subjective assessment can be made using this framework to help understand the adoptability of a new technology. In the following assessment, the five criteria for technology adoption suggested by Rogers, are scored (1=low and 5=high) for probes and for Yield Prophet®.

1. Relative Advantage

For a new idea to be adopted, it must offer some relative advantage over the current practice. Value in understanding soil moisture has become more apparent in the last decade. Prior to the availability of either system, rainfall was the surrogate measure for soil moisture. Growers and advisers understood the importance of soil moisture but had little knowledge of just how much water their soils could hold and how much moisture was in reserve for crop production for the remainder of the season.

Both probes and Yield Prophet® provide information on soil water status. Both provide the user with information about the position of water in the profile. Unless the probe is calibrated, only Yield Prophet® provides information on plant available water (in mm). Once a grower or adviser understands how much water is available in the profile, they are in a much better position to make management decisions.

Probes provide only a fraction of the information required to make the necessary range of management decisions. Yield Prophet® combines the basic soil water information with regional climatic data, crop phenology and soil available N to produce a range of yield outcomes based on historical rainfall or expected rainfall for the remainder of the season. The real strength and relative advantage of Yield Prophet® is as a learning tool for users to explore complex soil water and plant growth relationships.

While aspects of both probes and Yield Prophet® reports are simple, a full understanding in its use, interpretation and set up takes time, training and effort. However, because Yield Prophet® is much better integrated with all factors affecting crop production it is given a higher score.

Score: Probes – 4, Yield Prophet® – 5

2. Simplicity/Complexity

For an idea to be adopted, it must be simple. Complex ideas are hard to grasp and are less likely to be taken up. Soil probes offer relative simplicity. Users simply log on and receive information about the soil water level and rainfall. There is no other information provided that clutters thinking and users are free to use the data as they wish and can continue to make management decisions as they have in the past.

Yield Prophet® soil water reports are also simple. The 'bucket' representation has been widely used in discussions on soil water for some time. The soil water reports are embedded in the crop reports that contain much information and interpretation into probable yield outcomes. It is possible, that the inclusion of the soil water into the full crop report adds complexity and that first time users are overwhelmed at the information presented.

Yield Prophet® is more complex to use than probes.

Score: Probes – 5, Yield Prophet® – 3

3. Trialability

For a new idea to be adopted, it must be easily trialable. Probe installation requires expertise, however once installed the process of using them is straight forward. Many probe output users have been able to trial soil probes on their own or nearby properties through regional, state and federally funded programs that support their installation and training in use. In many cases, other growers and advisers can access probe outputs without bearing the cost of purchasing the unit or paying for installation.

Cost is a factor that limits trialabilty. At approximately $5000/probe plus ongoing support costs, growers may consider probes too expensive to trial. Where this is a barrier, growers can share access to probe data and hence reduce the cost to an individual. It must be remembered however, that the probe only provides information specific to the soil type and rainfall at a particular site.

Setting up Yield Prophet® requires a level of skill that requires first time users to undergo a reasonable level of training and follow up support. Users are required to select a soil type that represents their own soil type; this requires a matching of known measured soil characteristics that are available in the Yield Prophet® soils database for local soils. Comparisons of chemical and physical properties need to be made and many farmers and advisers may lack the skill, and therefore, confidence to conduct such comparisons. Selection of an existing soil type is becoming easier, with regional soil selection functions providing a short list of soils to choose from.

In summary, using Yield Prophet® as a way of increasing soil water knowledge is more difficult to trial than probes.

Score: Probes – 4, Yield Prophet® – 3

4. Observability

For a new idea to be adopted it must provide a reward in a reasonable time frame.

'Pay-back' time for either system is generally regarded as very good. Both systems improve farmers/advisers knowledge and understanding of what is happening to soil water during the cropping season. Both probes and Yield Prophet® can provide paybacks almost immediately which can continue throughout the season and beyond.

The added benefit of Yield Prophet® is the combination of soil water and soil available nitrogen data. In addition Yield Prophet® provides information on crop phenology and climatic data to simulate probable yield outcomes and allows a comparative analysis in a systematic way. It provides a science-based rigor to complex decision, and therefore, making Yield Prophet® far more useful beyond knowledge of soil water. Users of Yield Prophet® gain confidence in understanding all the factors and interactions involved in producing high water use efficient crops.

Score: Probes – 2, Yield Prophet® – 4

5. Compatibility

For a new idea to be adopted it must be compatible with current thinking. It should not be too many steps ahead of current practice and thinking.

From the perspective of improving knowledge on soil water alone, probes are more compatible with many users. They are a simple extension of a rain gauge and provide a translation between rainfall received and water in the soil. Probes provide some learning and develop a users thinking and understanding of the behaviour of water in a soil profile.

Until a decade ago, many growers and advisers simply thought about soil water in terms of: the profile is 'dry' or 'about half full' or 'close to full'. Little if any consideration was given to soil water in terms of mm of plant available water (PAW). Probe outputs provide a picture of water in a soil profile which is readily compatible with current thinking. Calibration of the probe is conducted by some groups to convert readings to mm of PAW. This is done without regard to consideration of chemical constraints that may limit root production and root growth at depth. Users can relate this information to their previous experiences and refine rules of thumb they have developed over time to make decisions rather than have a computer model do much of the interpretation that may challenge existing ideas and concepts.

Use of computer models is also less compatible with farmer knowledge and current experience. Farmers don't spend a lot of time using computer models to 'think through' a problem. They prefer to use their own experience to rationalise a concept and to make decisions. Probes are something they can purchase, operate, feel, see and touch, similar to a rain gauge or a piece of machinery. They make more 'sense' to growers than computer models.

Score: Probes – 4, Yield Prophet® – 2

In summary, the growth in the use of probes to understand soil water is easily explained using the framework above. Whilst not much difference exists in relative advantage of the two systems, probes perform better in the other assessment attributes, except for the observability test. Both probes and Yield Prophet® are driving the discussion on soil water. They are improving the understanding of the amount of the valuable resource that can (or cannot) be used to produce grain. Yield Prophet® takes the understanding of soil water and its relationship to potential yield to a new level. It provides much more information and interpretation of how crops use that resource in a way that probes cannot. Yield Prophet® integrates all the information required to make better decisions on crop production (Table 2).

Holy Grail

For optimum interpretation of soil water, combining probe outputs with Yield Prophet® could provide confidence, increase understanding and improve accuracy of soil water relationships between rainfall, evaporation and crop water use. If the soil moisture probe was calibrated, it could verify site soil water characteristics such as DUL, CLL (and hence PAWC), rooting depth and through flow.
In comparison, the model calculates daily water and N use, provides information on whether the crop is water or N stressed, and critically provides an assessment of the risk, using probability, of achieving a particular target yield, and how much N is required to achieve the target yield.

Whilst the debate may continue as to which is the best, both systems have played significant roles in improving growers and advisers understanding of soil water.

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Table 2. Outline of different methods for decision making by agronomists and farmers at critical stages of a crops development

Decision time	Guess	Back of the Envelope	Probe	Yield Prophet®
1 Pre sowing (deciding on a potential yield outcome and N requirements)	Using summer rain, fallow weeds, previous crop and estimate soil N and soil water for deciding on a yield potential and hence a N requirement (this methodology usually uses averages for production and N requirements).	Measure paddock soil water and soil N. Use WUE principles to calculate a yield for a dry, average and wet year. Estimate mineralisation over the season. Calculate N required for each season scenario (using 40kg N/t of grain yield).	Measure paddock soil water and soil N. Compare with probe data for the current year and previous years - calculate mm available if CLL is known from previous years. N estimated as per back of the envelope method.	Measure paddock soil water and soil N. Model potential yield (distribution curve) and N requirements to achieve a particular yield. Determine optimum sowing time by checking variety flowering dates and frost and heat shock risks during flowering and grain filling.
2 Sowing N (how much to apply)	To pre-drill N or not? Base decision on production in previous years.	If N and water are known at different depths then N requirements can be estimated. Mineralisation remains unknown.	Check current soil water status, if N is known at different depths then N requirements can be estimated from potential production. Note mineralisation remains unknown.	Requirements for N between sowing and GS30 can be determined (to ensure effective tillering can take place, without applying too much N). Available N and water stress are modelled. Potential yield of the crop and N required are modelled daily.
3 GS30 N (how much to apply)	Check the forecast - apply more N, quantity based on experience, if you think the crop might benefit.	Check the forecast – work out a potential yield based on WUE principles and apply more N if you think the crop might benefit.	Check current soil water status, if N is known at different depths then N requirements can be estimated from potential production. Note mineralisation remains unknown.	Daily N and water use and what is required are modelled to take the crop from GS30 to 45. Make a decision on N requirements based on probability of yield outcomes, PAW and rainfall forecasts. N and water stress are modelled. Loss of available N from waterlogging is modelled.
4 GS45 N (how much to apply)	Check the forecast, apply more N if you think the crop might benefit.	Check the forecast, apply more N if you think the crop might benefit.	Check how much available water (assuming you know CLL) is still in the profile and use the forecast to apply more N if you think the crop might benefit.	Daily N, water use, and N requirements for a target yield are modelled to take the crop from GS45 to grainfilling. Make a decision on further N based on probability of yield outcomes, PAW and rainfall forecasts.

Notes

Biopesticides - fresh hope for the future

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GRDC project codes: UCS00013; UCS00016; LUN00001

Keywords

biological control, insects, weeds, diseases, nematodes, molluscs

Take home messages

- **Biopesticides have been commercialised in Australia.**
- **They offer another avenue for managing recalcitrant insects, diseases and insects.**
- **Success with biopesticides depends on choosing the right target as well as the right agent.**
- **There are a large number of potential biopesticide agents but their commercial success depends on long term industry investment.**

Introduction

Biopesticides offer an innovative approach to the management of pests in farming systems using formulated microbial agents as the active ingredient. Microbes that have been used in this approach include fungi, bacteria, viruses and nematodes. Biopesticides are a viable adjunct to synthetic pesticides in a number of crops. The development of microbial biopesticides relies on agent discovery and selection, development of methods to culture the pathogen, creation of formulations that protect the organism in storage as well as aid in its delivery, studies of field efficacy, and methods of storage. Each microbial biopesticide is unique, in that not only will the organism vary but so too will the host, the environment in which it is being applied, and economics of production and control.

There are a large number of commercial products now available in most regions of the world, where biopesticides are being incorporated into farming systems. It has been projected that the market potential for these so-called "green products" could triple by 2020 and be worth over $4 billion (USD) (Bayer, 2013). The most successful examples of biopesticides include Dipel (a formulation of *Bacillus thuringenesis* - Bt), Gemstar (containing a nucleopolyhedrovirus – NPV) and T22 *(Trichoderma harzianum)*. The development of biopesticides is being driven by market opportunities such as pesticide resistance, changing consumer demands and the difficulty and cost of finding new synthetic pesticides. In Australia there are registrations for products based on Bt, NPV, *Trichoderma*, *Metarhizium* and *Beauvaria*. However, the number of registrations are relatively small when compared to the synthetic pesticides.

The use of biopesticides as a strategy in pest management can be applied to both native and introduced pests. However, the success of this type of biocontrol revolves around the costs of production, the quality of the inoculum and, most importantly, the field efficacy of the product.

Biopesticides are usually developed through collaboration with commercial companies with an expectation that they will recoup their costs and make a profit through the sale of the product.

Currently, in the Graham Centre at Charles Sturt University, there are a number of projects, at various stages of development, examining biological control of disease, insects, molluscs and nematodes affecting broad acre crops. These projects are variously funded by GRDC and CSU and have some level of commercial involvement.

Biocontrol of diseases

Blackleg disease of canola is a fungal disease of global importance. It is difficult to control by the use of chemicals and to date the best control measures are the use of genetically resistant canola cultivars and good farming practices. These cultivars display incomplete resistance to the disease and resistance breakdown has occurred in Australia.

Recent studies in other crops like radish and cucumber have identified a plant mechanism known as induced systemic resistance (ISR). This mechanism involves the use of naturally occurring beneficial soil bacteria, which switch on and activate the plant's defence system. The bacteria act somewhat like a vaccination to trigger the plants immune system. Such bacteria grow adjacent to and colonise a plant root system, this zone is high in nutrients released by the root system and consequently is heavily colonised by bacteria and fungi. The beneficial effects of rhizosphere bacteria have most often been based on increased plant growth, better seed germination and seedling emergence. These types of bacteria are now commonly called plant growth-promoting rhizobacteria (PGPR). PGPR use different mechanisms to suppress plant pathogens which include competition (nutrients and space), antibiosis production and inducing a plant's resistance mechanisms. This defence affects treated areas but also extends into non-treated areas and often even into newly developing plant parts. Systemic protection does not confer absolute immunity against disease but may reduce the severity by reducing lesion number, size and the extent of sporulation. Disease can be reduced by up to 90%. The potential of such bacteria is enormous for the reduction of disease and may be developed as seed coatings, drenches and powder applications depending upon the target pathogens, crop and the type of bacteria involved.

At Charles Sturt University we have isolated bacteria from the roots of canola and wheat in the southern cropping area. Some of these bacteria were from the rhizosphere and others were endophytic. They have been characterised in terms of their effect on growth of both wheat and canola, their ability to produce antibiotics active against the fungus that causes blackleg, numerous biochemical tests as indicators of their ability to suppress root pathogens and their ability to induce systemic resistance in canola against blackleg. Their ability to suppress disease in the glasshouse and in the field has also been assessed. Selected bacteria have been shown to reduce blackleg by induced systemic resistance in both sterile and non-sterile situations. The bacteria have then been ranked on desirable characteristics and the top 14 isolates have been identified using fatty acid analysis. This group includes endophytes and rhizobacteria, *Bacillus* and some *Pseudomonads* and all are plant growth promoters. Initial field results indicate that these bacteria are having positive effects on growth in the field. Furthermore, other species of bacteria have been isolated which have effects on other canola diseases and are comparable in efficacy to synthetic fungicides in field applications.

Biocontrol of molluscs

Four introduced Mediterranean snail species; *Cernuella virgata*, *Theba pisana*, *Cochicella barbara* and *Cochicella* acuta have become serious pests for the Australian grain industry in recent years. These pest snails cause heavy economic loss to farmers and the whole grain industry by contaminating the grain (wheat, barley, canola, lentil etc.), clogging harvesting equipment and downgrading the quality of grain. The lack of natural enemies of these pests in their distribution areas (most in SA, particularly in the Yorke Peninsula, some in VIC, TAS, WA and NSW) allow populations of these pest snails to increase rapidly.

This project was designed to investigate the possibility of developing a nematode based bioagent to control these pest snails in Australia. Nematodes have been successfully used for the management of slugs in over 14 European countries, and entomopathogenic nematode (EPN)-based bioinsecticides have been widely applied for the control of insect pests in Forestry, Horticulture and the turf industries.

In this project, a survey from south eastern Australia was used to isolate hundreds of indigenous potential EPNs from soil. From this collection, five nematode species with molluscicidal activities were selected and identified. The bacteria found associated with the nematodes were also isolated and identified. One of the bacteria, a strain of *Bt* molluscicidal activity (*Bacillus thuringiensis* DAR 81934), was found to be highly effective by itself and in combination with the nematode in killing the target snails. The complete genome of the *Bacillus* was sequenced and is a resource for further research. The nematodes were also found to be effective against slugs in the laboratory.

To be able to apply these organisms in the field, commercially available systems were used to produce the nematodes in Australia and internationally. Different systems were successful for different nematode species, allowing the production of concentrated nematode suspensions to be used in field trials conducted in South Australia over a number of years. It was found that the nematodes were best applied in the field in spring when the snails were laying eggs and moving on the soil surface. Unformulated nematodes caused up to 65% mortality in the field. However, synthetic snail baits provided up to 92% control.

This research has been discontinued as the cost of production of the nematodes was found to be too high for the use of the organism in broad acre agriculture in Australia.

Biocontrol of insects

Sucking insects like aphids can cause significant yield losses in agriculture due to the direct effects of feeding and the indirect effects associated with the spread of viruses. Current control of sucking insects relies on the use of chemical insecticides; however, these encourage the development of chemical resistance and suppress natural predator populations. Integrated Pest Management (IPM) programs that reduce the reliance on chemical pesticide therefore are likely to provide better management strategies for the future. As part of an IPM strategy GRDC have funded research into the discovery of biopesticides for the management of aphids in cereals and canola in Australia. The aim of the project was to develop pre commercialisation data for the registration of a biopesticide based on the fungus *M. anisopliae*.

A number of isolates of the fungus from Queensland and New South Wales have been isolated and cultured, with a number of the strains found to be highly pathogenic to a wide variety of aphid species common in Australia. Bioassays have been used to establish application concentrations and production efficacy of the strains is being established in the laboratory. All isolates are being compared to commercially available standards. Initial indications are that the Australian fungi are as efficacious as the internationally sourced commercial strains and are amenable to large scale manufacture.

Biocontrol of nematodes

At least four species of root lesion nematodes (RLN) in the genus *Pratylenchus* are considered serious pests of grain crops in Australia. *Pratylenchus neglectus* and *P. thornei* were chosen as the initial target species for this research project because of their prevalence and economic importance (recent estimates suggest losses due to RLN exceed $102M p.a. in Australia). Average incidence for both species across regions in Australia is 67-72% but with higher incidences recorded in the Northern and Southern regions (78-89%) compared to the Western region (43%). *P. neglectus* is more prevalent than *P. thornei* in the Western region but elsewhere the incidence levels are similar. It is important that the grains industry has robust control measures available to minimise the current and future losses from these nematode pests.

Currently, there are no nematicides registered for use in Australian cereal crops although some degree of management is possible with the use of resistant and/or tolerant crop cultivars, rotations incorporating poor host crops, manipulation of sowing time, provision of adequate nutrition and weed control within/between cropping phases. The cost of current control measures is estimated at $31OM p.a. for wheat and $81 M p.a. for barley.

The aim of this research project is to develop a bionematicide with activity against RLN on cereals. This strategy is based on the isolation and identification of naturally occurring beneficial microbes which are able to suppress the activity of the disease causing nematodes. The development of a new biological control product that is compatible with standard cereal cropping practices will provide growers with a wider range of disease management options for RLN and will add significant value to the grains industry.

The project has three initial research targets: the identification and evaluation of existing commercial biopesticides with potential suitability for this crop/pathogen system, the development of a *Trichoderma*-based bionematicide for cereal root lesion nematodes and the identification of indigenous strains of selected microbe groups that may have potential as bionematicides.

From initial surveys, a number of species of *Trichoderma* not previously recorded from Australia have been identified and their interaction with the organism responsible for crown rot and RLN are being evaluated in laboratory and glasshouse trials. A large screen of potential bacterial and fungal isolates have indicated that there are some which have potential as biological controls when compared with commercially available biopesticide formulations. Field trials in 2014 will establish whether these isolates can be used to manage nematodes in the field.

Conclusion

There are a number of advantages of the use of biopesticides over the use of conventional pesticides, including the minimal residue levels, control of pests already showing resistance to conventional pesticides, host specificity, and the reduced chance of resistance to biopesticides. This indicates an emerging, strong role for biopesticides in any integrated pest management strategy and an important involvement in sustainable farming production systems in the future. The main constraints to the production and use of biopesticides in Australia are the existence of facilities capable of producing the organisms economically and the systems for distribution and marketing of the products. These rely on the continued involvement of large corporations in the funding and development of these new management options.

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Opportunities with liquid systems

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Keywords

in furrow liquid injection, fungicides, inoculants, micronutrients, liquid fertiliser

Take home messages

- **There are multitudes of farming practices that involve the injection of liquid into the furrow that provide operational efficiency, crop protection, soil improvement and yield improvement benefits.**
- **Row to row, second by second, accuracy is critical for effectiveness when applying fungicides, inoculants and/or trace elements in furrow.**
- **Going liquid does not necessarily mean switching to liquid fertiliser.**
- **Implementation of a quality liquid injection system will provide excellent return on investment in a short timeframe.**

Overview

Liquid Systems (SA) has been building liquid injection systems for planters and seeders for the past 12 years. In that time the focus of liquid injection has moved from being focussed on N and P fertiliser application to the injection of a wide range of agricultural chemicals and nutrients.

With the maturing of GPS and mapping technology, soil data collection and analysis, tillage and planting equipment, the future of farming is the development of decision making tools and methodologies that allow farmers to intelligently prescribe seeding regimes that optimise the use of inputs, water and the land.

Precision in furrow liquid injection will be a key enabling technology, providing the means to deliver liquid products to improve soil conditions and optimise the establishment of healthy crops.

In practical terms for farmers and advisers, there is a vast range of different in furrow liquid applications that can be started this season that will provide improved yield, crop protection, and operational efficiency improvements. Our customers' stories will tell you, that the return on investment in a precision liquid injection system is normally rapid and potentially huge.

Liquid injection applications

Currently known, in furrow liquid injection applications that have been implemented by Liquid Systems (SA) customers are summarised in the table below.

Table 1. Liquid injection applications and benefits

Application	Benefits
Liquid Fertilisers Variable rate, multiple product fertiliser application	Provides operational efficiencies compared to spreading or in furrow granular. Reduced risk, $$$ savings from not spreading fertilisers pre sowing.
Micronutrients Apply micronutrient solutions in furrow when seeding.	Treat deficiencies or lock up of micronutrients in the soil before they impact crop health. Overcome Herbicide Burden in Soils causing lock-up of micronutrients $$$ savings from reduced spraying requirements during growing season. $$$ crop yield improvement
Inoculants for Legumes In furrow, with the seed application of inoculants with water when sowing legumes.	Much simpler operation than treating seed prior to sowing. Generally more effective than seed treatments in adverse conditions. Better germination rates than seed treatments. $$$ savings through reduced seed rates required Increased residual soil nitrogen for follow-on crops.
Fungicides In furrow application of fungicides.	Protection of crops against a range of fungal diseases in cereals, oilseeds and cotton. $$$ savings through reduced spraying required throughout the season.
Soil Wetters Apply soil wetters in furrow or surface band at seeding.	$$$ yield improvements from improved rainfall harvesting and water use efficiency. Non-wetting soils become viable and productive cropping land.
Soil Conditioners Apply a variety of liquid solutions to improve soil characteristics.	Improve soil properties such as water harvesting, structural stability, nutrient availability, nutrient retention, pH and EC.
Nitrogen Stabilisers Addition of nitrogen stabilisers to liquid nitrogen fertilisers injected in furrow.	Inhibit loss of N through reduced nitrification and volatilisation. $$$ Savings through reduced nitrogen fertiliser requirement throughout the season.
Insecticides, nematicides In furrow application of pesticides.	Protect crops from destructive insects and nematodes.
Multiple Liquids, Varying Soil Depths Independent rate control of multiple liquids, delivered at different locations in the soil profile.	Optimise placement of different products to get best usage. Independent rate control of separate liquids delivers input usage efficiencies. Avoid seed toxicity issues by appropriate separation of fertilisers from seed.
Section Control Mapping based section control shuts sections of the planter or seeder on and off to maximise use of land and avoid overlaps.	Optimise land use on irregularly shaped paddocks. Increase input efficiency by reducing overlaps and gaps. $$$ savings and yield improvements.
Variable Rate Mapping Use historic map based yield, input application and soil analysis data to define optimised input application maps. Use precision ag systems to deliver inputs as mapped.	Optimise return on inputs. $$$ savings
Direct Injection Directly inject neat chemicals into a main stream	Avoid chemical wastage from tank mixing. Overcome some incompatibilities by avoiding tank mixing. Independent rate control of injected chemical provides flexibility and input use efficiency.

Importance of accuracy

The effectiveness of nearly all in furrow liquid applications is very much dependent on the precision and accuracy of the equipment being used.

To ensure every seed(ling) gets the required amount of liquid, in furrow liquids need to be delivered in a continuous stream with even distribution across the rows. Without row to row, second by second accuracy, the furrow is not treated uniformly and plants may suffer from over or under application of product. This can impact germination, plant growth and ultimately crop yields.

These impacts may be even more pronounced at the very low application rates that farmers want to achieve at the present time.

Natural dispersion of liquid products through the soil cannot be relied on to rectify uneven application by the liquid injection system.

Farmers have a tendency to seek out cheaper options or build their own systems, but in most cases this is not economically sound. They will fail to get the optimal benefit of their liquid injection regimes due to inaccurate or uneven application and operational issues.

Key features required of a liquid injection system

To provide effective in furrow injection of liquid products, a liquid injection system must have the following characteristics:

- Accurate rate control,
- integration with mapping based systems for variable rate control,
- accurate/even distribution on a row to row, second by second basis,
- components made from chemical resistant materials,
- provides tank agitation,
- clean water flush function,
- static testing capability; and
- section control capability (as an option).

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Notes

Rhizoctonia control improved by liquid banding of fungicides

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Keywords

Rhizoctonia, banding fungicides, liquid injection

Take home messages

- **SARDI and DAFWA field trial results show banding fungicides above and below seed, below seed only or below seed combined with a seed treatment can improve control of *Rhizoctonia*.**
- **APVMA is currently reviewing submissions to enable banding of selected fungicides to improve control of *Rhizoctonia*; if approved, registration will be granted in 2015.**
- **Permits have been approved for large scale evaluation in 2014 – watch out for local field days conducted by Syngenta and Bayer CropScience.**
- **Fungicide treatments alone will not eliminate patches and need to be used as part of an integrated management program.**

Introduction

New fungicides and methods of application are being developed to help prevent yield losses caused by *Rhizoctonia*. Several products have recently been registered for suppression of *Rhizoctonia* (see Cereal Seed Treatments 2014 Factsheet).

The first field trials to evaluate banding fungicides for *Rhizoctonia* control were conducted in WA in 2009 at Katanning and Northam (with funding from GRDC) and SA in 2010 at Geranium (with funding from SAGIT/Syngenta). In the SA trial the best treatment was shown to be a combination of fungicides applied as "split" streams on the soil surface and in-furrow below the seed. This combination produced a 0.51 t/ha yield responses in knife point and rippled coulter sown treatments (knife point yielded 0.21 t/ha more than rippled coulter). The application above the seed was targeted to protect the crown roots and the stream at the base of the furrow to protect the seminal roots.

This paper summarises the yield results from most of the field trials conducted in SA and WA from 2011 to 2013 to evaluate different ways of banding fungicides to reduce yield losses caused by *Rhizoctonia* and generate efficacy data to support label registration by the APVMA.

Rhizoctonia – key features

Research projects in SA and WA funded by GRDC and SAGIT have made significant progress in understanding *Rhizoctonia solani* Kühn AG-8 and improving management options. This fungus is adapted to dry conditions, with most inoculum occurring in the top 3-5 cm of soil. It develops rapidly after the opening rains to form a hyphal network, and can attack crop roots throughout the growing season. Damage is greatest when root growth is restricted and/or soil temperatures drop to around 10°C. It is the severe damage to seedling roots which results in the characteristic bare patches.

In many early sown crops root damage is delayed until around tillering when soil temperature drops to around 10°C, this slows root growth and the fungus can attack seminal and crown roots causing uneven crop growth. Uneven growth, rather than bare patches, is now the most common symptom in the majority of crop paddocks affected by *Rhizoctonia*.

Inoculum levels increase during the growing season, especially during spring, and reach maximum levels as the crop dries off. Cereals and grasses are the main hosts; cereals following cereals or grassy pastures are at greatest risk.

Results and Discussion

The APVMA is currently considering applications from Syngenta and Bayer CropScience for label recommendations to band fungicides for *Rhizoctonia* control in wheat and barley. Only the results of a Syngenta coded product (SYNSIF1) are presented in this paper to avoid supporting off-label use of other products.

Table 1. Summary of net wheat yield responses (t/ha) in *Rhizoctonia* fungicide application trials with SYNSIF1 and Vibrance™

Site	Year	Pre-sow Rhizo DNA (pg/g soil)	Untreated yield (t/ha)	Vib.	Vib. + IF rate 1	rate 2 IF	rate 3 IF	rate 2 (½ Sur + ½ IF)	rate 3 (½ Sur + ½ IF)
Weetulta (SA)	2013	205	0.88				**0.40****		**0.49****
Lameroo (SA)	2013	106	2.29	0.09	**0.18****	**0.13****	**0.19****	**0.24****	**0.20****
Wynarka (SA)	2013	257	1.79	0.03	**0.22****	**0.28****	**0.21****	**0.38****	**0.53****
Katanning(WA)	2013	6	4.28	0.04	0.00	-0.02	0.04	**0.15***	**0.23***
Karoonda (SA)	2012	138	1.36	**0.25****	**0.47****	**0.33****	**0.42****	**0.39****	
Port Julia (SA)	2012	102	2.88	0.02	**0.14***	**0.14***	0.09	0.11	
Lake Grace (WA)	2012	65	0.71	**0.09***	0.05	0.02	**0.08***	**0.11***	
Keith (SA)	2011	76	2.70	0.02	0.07	0.14			
Minnipa (SA)	2011	109	1.98	**0.08****	**0.09****	**0.12****			
Yumali (SA)	2011	219	1.33	0.06	**0.20****	**0.20****		**0.19****	
Corrigin (WA)	2011	62	2.84	0.00	0.09	**0.26****			
Ongerup (WA)	2011	161	1.82	0.12	-0.09	0.00			

** Significant (P < 0.05) or ** Significant (P < 0.001), compared to untreated plots*

Vib = VibranceTM seed treatment applied at 360 ml/100 kg seed, IF = SYNSIF1 applied in-furrow (3-4 cm below seed), Sur = SYNSIF1 applied on furrow surface.

Table 2. Summary of net barley yield responses (t/ha) in *Rhizoctonia* fungicide application trials with SYNSIF1 and Vibrance™

Site	Year	Pre-sow Rhizo DNA (pg/g soil)	Untreated yield (t/ha)	Vib.	Vib. + IF rate 1	rate 2 IF	rate 3 IF	rate 2 (½ Sur + ½ IF)	rate 3 (½ Sur + ½ IF)
Lameroo (SA)	2013	106	2.77	**0.21****	**0.17****	**0.30****	**0.31****	**0.40****	**0.37****
Wynarka (SA)	2013	257	1.93	0.09	**0.62****	**0.69****	**0.53****	**0.69****	**0.87****
Kojonup (WA)	2013	22	4.38	0.04	0.18	-0.21	**0.36***	**0.25***	0.13
Karoonda (SA)	2012	138	2.63	-0.12	0.18	**0.44***	**0.49***	0.24	
Port Julia (SA)	2012	102	2.99	-0.03	0.01	0.16	-0.15	0.15	
Calingiri (WA)	2012	13	1.20	0.05	**0.17****	**0.25****	**0.26****	-0.05	
Keith (SA)	2011	76	2.93	-0.03	0.18	0.09			
Minnipa (SA)	2011	109	2.61	0.09	0.12	**0.28****			
Yumali (SA)	2011	219	1.53	-0.07	**0.20***	0.12			
Salmon Gums (WA)	2011	136	0.46	0.01	0.0	-0.01			

** Significant (P < 0.05) or ** Significant (P < 0.001), compared to untreated plots*

Yield responses for six main treatments, all sown with knife points, are presented in Tables 1 and 2 for wheat and barley, respectively (note: some treatments were evaluated in recent years only). The results are presented as net yield increases (t/ha) for each treatment, with the site untreated yields (t/ha) and pre-sowing *Rhizoctonia* levels included to help characterise each site. *Rhizoctonia* field trials are inherently variable and it was difficult to detect statistically significant yield responses less than 10% and sometimes larger.

The treatments producing the most consistent yield responses had fungicide applied on the furrow surface behind the press wheel (above the seed) in combination with fungicide applied as a stream at the base of the furrow about 3.5 cm below the seed. This "split" application produced significant yield responses in wheat in six of the seven trials at the medium rate (rate 2) and all four trials at the high rate (rate 3). In barley, significant responses were seen in three of the six trials at the medium rate and two of the three trials at the high rate.

Application of SYNSIF1 in-furrow only produced significant yield increases in wheat in seven of the 11 trials at the medium rate and five of the seven trials at the high rate while in barley it was five of the 10 trials at the medium rate and five of the six trials at the high rate.

Banding below the seed at the low rate in combination with Vibrance™ seed treatment increased yield significantly in wheat in six of the 11 trials and in barley four of the 10 trials. Seed treatment alone increased yield significantly in two of the 11 wheat trials and one of the 10 barley trials.

The surface application treatment applied behind the press wheel in SA was applied using a low volume narrow angle nozzle set to spray along its narrow side creating a narrow band approx. 2 cm wide. One trial conducted in SA in 2013 found no significant differences when the surface band was applied as a fine jet, a 2 cm wide, or an 8 cm wide surface band. Results may have been different in a lower rainfall year. In WA, the surface band treatment was applied as a trickle in a separate pass following the first pass application of fungicide as a trickle below the seed using GPS controlled auto-steer.

Summary of other factors that reduce risk of *Rhizoctonia*

- SARDI/DAFWA field trials with Vibrance™ and EverGol® Prime seed treatments showed that these products increased yield by 5% on average.
- Non-cereals, especially canola and pulses, provide useful reduction in *Rhizoctonia* levels for the following crop.
- Frequent summer rainfall combined with summer weed control.
- Autumn "green bridge" controlled.
- Early sowing and soil disturbance below seed facilitates root growth down soil profile.
- Knife point soil openers reduce risk of *Rhizoctonia* compared to discs.
- Consider increasing seeding rate to reduce impact of lost tillers from *Rhizoctonia* damage to crown roots.
- Encourage rapid seedling vigour by applying adequate nutrition – in particular minimise N deficiency by banding N below the seed and do not incorporate stubble.
- Address in-crop nutrient/trace element deficiencies with foliar application.

Potential high soilborne disease risk in 2014

- Conditions in 2013 favoured increases in *Rhizoctonia*, crown rot, take-all and Pratylenchus.
- If summer rainfall continues to be low.
- Risk will be further increased if season breaks late and soils are cold.

Identifying high risk paddocks

If sowing cereals back on cereals in 2014 then consider a PreDicta B test.

Important change to sampling strategy for PreDicta B

- Target sampling along the rows of the last cereal crop.
- Collect three 1X10 cm cores (AccuCore) from 15 different locations within the target sampling area/paddock.
- **Addition of stubble (if present) – at each of the 15 sampling locations, select one piece of stubble from the base of a cereal plant or grassy weed, discard stubble above the first node and add the lower portion to the sample bag.**
- Inadequate sampling is likely to result in a failure to warn growers of a significant risk, especially from crown rot. Addition of stubble that includes the base of the plant should also improve detection of take-all and *Rhizoctonia* (research to improve sampling strategy is continuing).

Future work

- Explore ways to reduce impact of *Rhizoctonia* in crops sown with disc seeders, including optimising fungicide placement and reduced hair pinning of inoculum.
- Better understand the role of in-season rainfall.
- Investigate varietal differences in hosting *Rhizoctonia*.

Further reading

GRDC Factsheet March 2012

http://www.grdc.com.au/Resources/Factsheets/2012/03/Management-to-minimise-Rhizoctonia-disease-in-cereals

Cereal Seed Treatments 2014 Factsheet by Hugh Wallwork available from: http://www.sardi.sa.gov.au/__data/assets/pdf_file/0017/86102/Cerealseedtreat2014_Web_Version_.pdf

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Notes

Seamless prediction - environmental intelligence for today, this week, next month, next season

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Keywords

climate, seasonal forecasting, weather, POAMA

Take home messages

- **The understanding of weather and climate influences continues to improve.**
- **Major upgrades have occurred, or are occurring in weather and climate forecasting systems.**
- **Useful environmental information is becoming available for industry from short time to seasonal timescales.**

Introduction

The last 10 years has seen major improvements in both the understanding of weather and climate influences on Australia, and in weather and seasonal forecasting systems in use by the Bureau of Meteorology. These changes and the application of new shorter term and seasonal forecasting information such as MetEye, the BoM POAMA model and Heatwave warning systems for agricultural activities will be explored in this presentation.

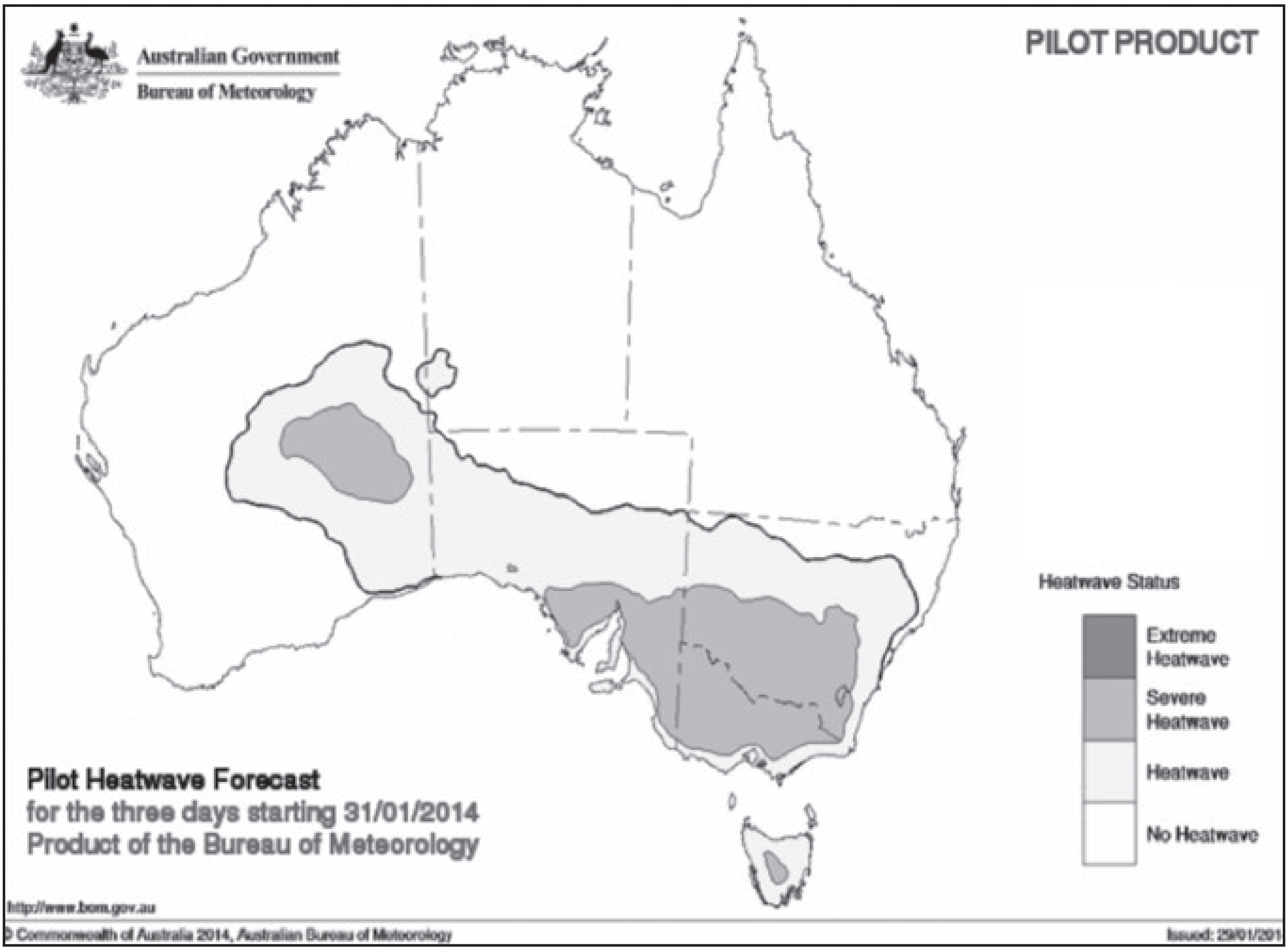

Figure 1. Heatwave forecasts for late January 2014.

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Increasing agricultural production by alleviating soil constraints in South Australia

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Keywords

production, soil constraints

Take home messages

- **About 40 per cent of the area under broadacre agriculture in South Australia has issues that limit soil productivity.**
- **Improving the texture and nutritional status of infertile water repellent sands, and the soil structure in heavier soils, provides a great opportunity to increase broadacre production.**
- **The potential to increase food production, through implementing available technologies addressing soil constraints across South Australia, is worth around $600 million per annum.**
- **The 'New Horizons' initiative has been developed by PIRSA to fast track the benefits to community and the economy.**

Introduction

There are around 10.7 million ha of land under broadacre agriculture in South Australia. Production on about 40 per cent of this area (4.1 million ha) is severely limited by soil issues, which can be addressed through soil modification. The greatest opportunities appears to be in radically improving the texture and nutritional status of infertile water repellent sands (2.8 million ha) and improving soil structure in heavier soils with sodic and or poorly structured clay sub-soils (1.7 million ha).

Previous trials and demonstrations funded through the Department of Environment Water and Natural Resources (DEWNR) and Caring for Our Country have shown large increases in production are possible, however results have been variable and somewhat unpredictable. 'New Horizons' is a pilot programme to determine the causal relationships; the practicality of amelioration; the potential production benefit; and what is required to realise this benefit.

This document provides a summary of areas of potential opportunity and also a brief description of the most likely and most beneficial outcomes.

Indicators of soil health and water use efficiency

Soil organic carbon (SOC) is one of four indicators of soil condition identified in the national land and water audit. SOC levels are largely determined by the amount of input of carbon (often related to rainfall, but also to water use efficiency (WUE)) and the clay percentage. Analysis conducted by DEWNR of soil data from the State Land and Soil Information Framework (SL&SIF) has identified that, while there is large variability in SOC within rainfall and soil texture categories, there are correlations with soil texture and structure, particularly in subsoils.

Analysis of production data conducted by McCord and Payne in the 1990s identified that much of the agricultural area of South Australia delivers yields in the range of 40 to 70 per cent of the French Shultz potential. Therefore, there is a large untapped opportunity to increase yields on these soils.

Major areas of opportunity

Analysis conducted by DEWNR and PIRSA has identified that the largest area for potential gain through soil modification are as follows.

Sandy soils

There are around 2.8 million ha of sand and loamy sand soils under agricultural production in South Australia. Production on these soils often achieves only 40 to 60 per cent water use efficiency. These soils are low in organic carbon, can be non-wetting and have low nutrient and water holding capacity.

A large proportion of these soils have very infertile, bleached, A2 horizons. Root systems in the A2 horizon are often weak and diminish rapidly with depth, rarely penetrating to the B horizon below. This would severely restrict nutrient and water uptake by crops and pastures. The cost of foregone production on these soils has been estimated at around $760 million per annum (DEWNR 2004). There are also additional costs resulting from increased wind erosion potential and difficulties in weed control.

Options to address issues on sandy soils are outlined below.

Clay addition

The addition of clay to these soils was first undertaken almost 40 years ago by Clem Obst, a farmer in the south east of South Australia. Since then there has been broad uptake of the technique, however results have been mixed. While a review of claying trials in South Australia showed an average yield increase of 70 per cent, individual results ranged from 0 to 100 per cent. A typical example is detailed in Figure 1. This practice requires a large investment by farmers and the lack of consistent results has constrained uptake and the potential production gains that can be obtained.

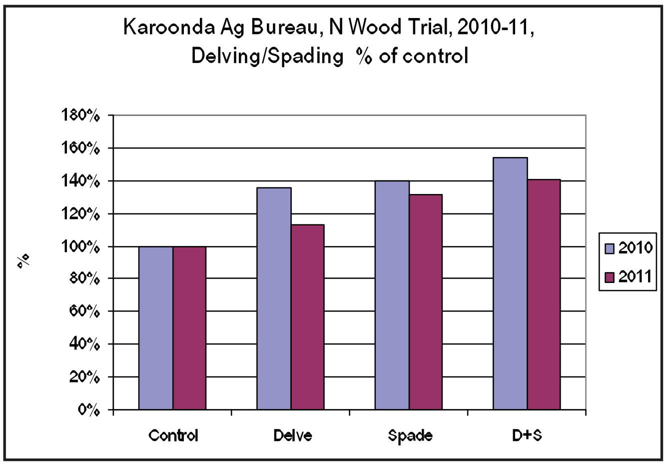

Figure 1. Karoonda clay trials (Tonkin 2012).

Deep nutrition and the addition of organic matter

Research conducted at Wharminda by Doudle et al (2004) has shown that yields can be increased by up to 100 per cent through the addition of deep nutrients to these soils. Trials using combinations of nutrients banded at different depths to 80 cm identified that the placement of major nutrients (N, P and trace elements) to 40 cm delivered the best results. More recently Masters and Davenport (2012) have shown that deep incorporation of organic matter can also deliver substantial yield increases in both clayed and un-clayed sands.

Questions and answers

Analysis of 60 clayed and un-clayed sites (Schapel and Davenport unpublished) suggests that the best results are obtained where sufficient clay is added to overcome non-wetting in the topsoil and allow clay incorporation into the bleached A2 horizon. Schapel (2012) has also identified that SOC stocks (0 to 30 cm) can be doubled where appropriate modification practice is applied. This not only supports increased productivity but also provides the opportunity for a large emission offset (70 to 75 t/ha CO_2e).

Although there is understanding of the constraints, the most effective and economical treatments are yet to be confirmed. Questions include those outlined below.

Clay distribution.

The distribution of clay is also a factor with clay clod size appearing to affect both root distribution and organic carbon content. Schapel (unpublished) has identified that there is a relationship between clay clod size and organic carbon concentration of the clod (Figure 2). One study has also suggested that roots are attracted to small clay clods rather than large clods.

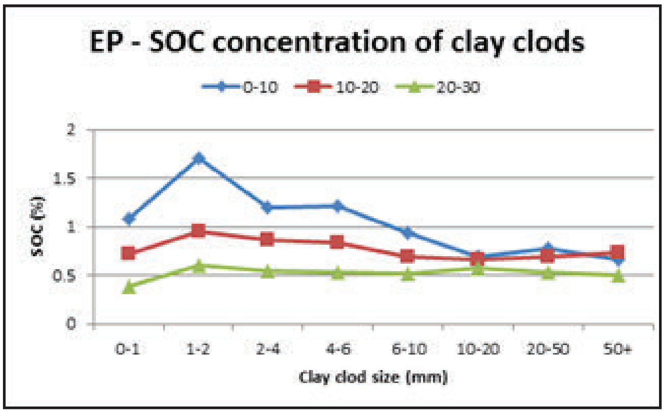

Figure 2. Relationship of sand and clay clod size to SOC.

The role of added organic matter.

Demonstrations have identified that the addition of organic matter has delivered increased yields and higher soil organic carbon levels, with one site on Eyre Peninsula showing increased yields for at least 3 years (Figure 3). This trial details yield data (t/ha) from 2 sets of treatments (N=North and S=South) on a shallow sand over clay site spaded in 2009. Analysis of a site on Eyre Peninsula, and one in the south east, has identified that the root mass of the 10 to 30 cm layer can be doubled through claying and tripled with the addition of clay and organic matter, thereby enabling greater nutrient and water uptake.

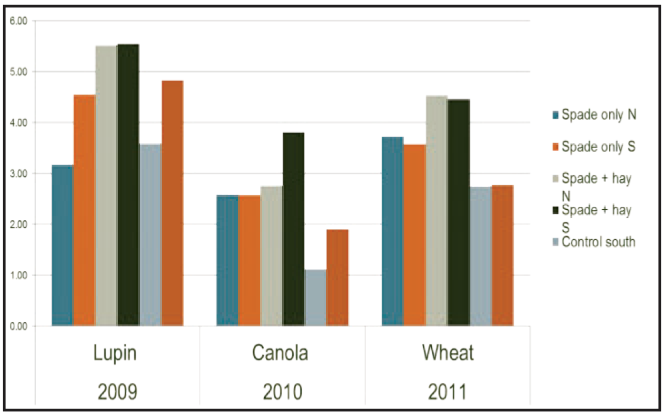

Figure 3. Edillilie Trial Data.

Deep nutrition.

The length of the benefit; different combinations of nutrients; and whether the production gains can be enhanced by coupling with added ameliorants, such as clay and organic matter, need to be confirmed. As not all soils need a full range of nutrition treatments, development of a 'least cost package' determining the nutrition requirements to 40 cm for individual soils would be a major development.

Sandy loam and heavier soils with sodic, poorly structured or bleached horizons

Similar to sands these soils have constraints impacting on root development and also have low SOC levels in subsoil horizons. However, there has been very little research in South Australia conducted on the factors causing these issues on these soil types.

Data collected from red brown earths in the national Soil Carbon and Research Program (SCaRP) recorded soil carbon stocks to 30 cm ranging from 13 t/ha to 72 t/ha. There is a poor correlation between bulk density and carbon except where bulk density exceeds 1.6 g/cm^3. Where bulk density exceeds this level anywhere in 0 to 30 cm, low carbon stocks are found.

In the past, deep ripping has been used at various times to address poor structure, however, results have been mixed and benefits have generally been short term. This could be expected as without addressing sodicity (by the addition of gypsum) or the poor structure of highly weathered clays (by the addition of organic material and or calcium) to the affected depth, the cause of poor structure will not be ameliorated.

The lack of suitability of equipment to deliver amendments deep into these soils has been a constraint to adoption. The development and availability of equipment such as the DRS plough that combines deep ripping with the incorporation of ameliorants to 20 cm now makes this practical on a broadacre basis. Further development is needed in this area to determine the form, amount and depth of incorporation of amendments to deliver the most practical and economic benefits.

New horizons

'New Horizons' is an initiative to capture the potential of an additional $600 million increase in food production per annum in South Australia; increase long-term storage of carbon; and obtain a significant reduction in soil erosion risk.

This program will focus on soils under broadacre agriculture in this state. Specifically, soil issues limiting agricultural production that can be addressed with innovations in soil amelioration and crop husbandry.

An adaptive management design model for the research and extension program will follow a cycle of design, implementation, monitoring, evaluation, communication and review. PIRSA is currently exploring opportunities to deliver this major strategic initiative and is currently talking to potential partners.

Given the size of the opportunity and the long term benefit New Horizons can provide, support from grower organisations is vital to ensure the maximum benefit is achieved.

Conclusion

Analysis of the potential for uptake and economics conducted by PIRSA suggests that the potential to increase food production, through implementing available technologies addressing soil constraints across the state, is around $600 million per annum. This increase is generated by an increase in production from higher crop yields and also increases in pasture growth supporting higher stock numbers per area. The figure also accounts for some expected shifts from pasture to higher value cropping as a result of the improvements in soil fertility. Adoption modelling suggests that measurable increases in food production will occur after three to four years from the start of the program.

The program will also deliver significant environmental gains. There will be reductions in erosion risk and recharge to saline water tables over a large proportion of the agricultural area. Research has also demonstrated that increases in long-term storage of soil carbon following soil modification can occur. This could realise an emissions offset exceeding 200 mega tonnes (Mt) of CO_2e compared with South Australia's total current annual net emissions of approximately 30 Mt.

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Notes

Soil amelioration

Roger Groocock,
Groocock Soil Improvements

Keywords

ongoing management, deep mixing, knowledge of soil profiles.

Take home messages

Take home messages

- **The development of delvers and the timing of delving, such as when the clay is near to the plastic stage, results in a much cheaper operation, the option to delve deeper and a dramatic increase in yield.**
- **The consistent increase in biomass above and below the ground was also very important, potentially resulting in increased organic matter in the soil.**
- **With good ongoing management of our water repellent soils, productivity gains are at least maintaining.**

Farming north of Bordertown, SA on sandy soils has been a challenge and a great journey for Sue and myself since we started in our own right in 1979.

When the water repellency issue emerged as a having a serious impact on production, we embraced the clay spreading idea on the deep rising ground.

In the early 90s the Wirrega Agricultural Bureau members noticed that our shallow duplex sandy loam over clay was becoming water repellent. The clay from these areas, when spread and incorporated, gave us great results on the deep sands and so the thought was put forward – why not lift some of the clay with tynes and mix it in the top soil? This was the beginning of clay delving in our area.

The first Landcare funded local trial, using a trench digger 125 millimetres wide and 600 mm deep, spaced at 1.2 metres apart and incorporating gypsum, lifted yields from 1.8 to 4.5 t/ha. This gave us the target of trebling yields.

The trench digger was very expensive, so an economical way to undertake the process had to be found.

While attending a water repellency workshop in Western Australia, I saw Dr Paul Blackwell from DAFWA demonstrate a light weight modified rabbit ripper (delver configuration) which led us to approach Professor Riley from the University of SA to build a delver to handle the job. This was the second Landcare funded trial.

Being in a position to view the rainfall simulation work that David Malinda from SARDI demonstrated to us, we could see the big increase in infiltration rate on the clayed (spread and delved) sites compared to no treatment. The simulated application rate on only a 3 per cent slope showed the small pieces of organic matter floating away with the runoff water.

We started clay delving to avoid water repellence in the shallow soils. This led to the recognition of more important subsoil constraint issues, such as:

- low fertility – some in defined layers down the profile;
- compaction – both natural and also wheel compaction;
- silicon sand particle crust on the dome structured clays;
- sodic clay layer;
- bleached sand in A2 layer; and
- variable pH down profile.

Clay spread country is always going to be limited until organic carbon is lifted, which can be achieved with a crop phase followed by a lucerne based pasture phase before coming back into crop.

The further development of delvers and the timing of delving, such as when the clay is near to the plastic stage, results in a much cheaper operation and the option of going to a deeper depth.

Let nature do its bit, wetting and drying over summer. The clay cracks open and breaks down the lumps before smudging and mixing. Then there is an opportunity to spade green material 300 mm deep in spring and then sow summer producing crop, such as fodder rape or millet.

In 2010-11 our fodder rape was knee high twice and gave two grazings from January to the end of March, putting 100 kg of weight on 90 weaner heifers at $1.60/kg. Then in 2011, the same paddock yielded 2.8 tonne of wheat.

We were able to change crop rotation to enhance soil health, for example we grew beans on soil where previously it was not possible.

Trial results 12 years after treatments in 1994 - operation fine tune

While there has been a general lift in returns of 70 to 75 per cent from pre-1990, this year's water logging was not good on the shallow soils. There have been difficult finishes to the recent seasons,

Table 1. Old Landcare trial site, sown to barley in 2006

Treatment	kg/ha	% site mean
Slotting 30cm Control	1175	115
Slotting 60cm 1t/ha gypsum	1156	113
Slotting 60cm 1/2t/ha gypsum	1153	113
Ripping 1994 45cm 1t/ha gypsum	1139	111
Ripping 1994 30cm 1t/ha gypsum	1138	111
Ripping 1994 30cm	1079	105
Slotting 30cm 1t/ha gypsum	1029	101
Slotting 60cm Control	1022	100
Slotting 60cm 2t/ha gypsum	993	97
Ripping 1994 45cm	981	96
No Treatment Control	729	71
Surface 1t/ha gypsum	690	67
Site mean	1024	
CV%	8.49	
lsd (0.05)	163.7	

and early rain cut-off. The grain yield is one result, but the consistent increase in biomass above and below ground is also a very important result with potentially more organic matter going into the soil.

Lessons learnt

- Soil pits are critical to see what is happening.
- Lifting clay content in A1 and A2 to at least five to 10 per cent which
  a) retains water in the root zone longer, and
  b) deeper more extensive root structure therefore more organic matter.
- Need to know the pH and also the chemical make up of the clay.
- Manage nutritional balance, such as trace elements and pH, using gypsum, lime, and potassium.
- The placement of trace elements into the A2 zone should be broad band not pencil stream behind deep tynes – alabamas.
- Need to find deep rooted plants to use modified soils.

Conclusion

With good ongoing management, productivity gains are at least maintaining. These productivity gains have always funded the next year's activities.

Acknowledgements

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Notes

Refining snail chemical control

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SARDI

GRDC project codes: DAS00134, YPA00002

Keywords

snails, bait, spreaders, stubble, Perlka®.

Take home messages

- **Baits do kill juvenile snails.**
- **Stubble and/or green plant material reduce uptake of snail bait by juvenile snails.**
- **A baiting program that is integrated with appropriate stubble and weed management at pre-sowing is likely to optimise snail control.**
- **Calibrate your bait spreader to optimise the effectiveness of your baiting program.**
- **Perlka® did not have a significant effect on reducing snail populations in caged field trials.**
- **The effectiveness of bait product and bait size differs between the pest snail species; once fully researched, future bait program recommendations will be tailored to the species being targeted.**

Background

Four exotic snail species have become established in Australia as major pests of grain crops. They cause significant economic losses through yield loss as a result of feeding damage and through contamination and grain loss at harvest. Market access is continually threatened by these exotic snails: two round species, the vineyard snail *Cernuella virgata* (Da Costa) and the white Italian snail *Theba pisana* (Müller), and two conical species, the pointed snail *Cochlicella acuta* (Müller) and the small pointed snail *Prietocella barbara* (L.).

These snails are widespread across southern Australia and require a year-round integrated management approach including cultural, mechanical and chemical controls. Baiting is a major tool, but the control achieved is often mediocre. Several variables influence the effectiveness of baiting programs and these include timing, species and age of snails; properties of commercial baits; and environmental conditions, including weather, soil moisture, stubble load and the supply of alternative food. Factors such as stubble and alternative foods can interfere with bait programs.

An effective snail baiting program relies on an even distribution of baits at appropriate rates over affected areas. A collaborative YPASG/SARDI GRDC fast track project was funded to investigate the effectiveness of commercial spreader machinery, designed for fertiliser application but used for bait, in achieving even distribution of baits at effective rates.

Alternate products have been suggested to provide control of snails in field crops. The horticultural fertiliser Perlka® (granulated calcium cyanamide) was previously tested for effects on snail eggs by SARDI in laboratory trials before current field testing.

This paper reports on the effects of stubble residues, crop plants and bait fragmentation on the efficacy of baiting programs. General outcomes of bait spreader machinery tests are discussed and the outcomes of Perlka® field tests are presented.

Methods

Influence of crop and stubble on bait efficacy to control juvenile snails

Location: Laboratory trial, Waite Campus, SA

Replicates: 6

Plot size: Plastic 4L Decor containers containing soil from Warooka, SA to depth of 4cm, and enclosed with wire frame and stocking material

Treatments: (i) bare soil, (ii) canola seedlings (30 plants at cotyledon/first leaf stage), (iii) stubble (fine chickpea stubble 18 months old from Urania, SA), (iv) canola + stubble (30 plants + chickpea stubble)

In August 2013, arenas were prepared with treatments and 30 *T. pisana* juveniles (10 to 20 days old; 2 to 3mm diameter). Two Mesurol (2 per cent methiocarb) snail baits (10mm long) were placed centrally within each arena. Snail mortality was assessed after one week. This experiment was repeated in September with C. acuta juveniles (2mm diameter). Transformed mortality values were analysed by ANOVA and posterior pairwise comparisons by Tukey HSD.

Effectiveness of spreader machinery in distributing snail/slug baits

Location: Urania, SA

Treatments: Spreader machines – Amazone, Bogballe, Vicon, Kuhn (Lehner and C-Dax)

Bait products – Meta, Metarex, Slugger (4mm diameter), Slugout

This was a YPASG-led trial (YPA00002) funded by GRDCs fast track program intended to investigate the effectiveness of common fertiliser spreaders to evenly distribute snail/slug bait products to achieve recommended numbers of baits per metre squared. Machines were tested with manufacturer representatives onsite and a qualified calibrator prepared the machinery settings and made modifications as appropriate. Multiple runs over 50 catch-trays were made with each machine and bait product combination. Bait weight and number (and in some instances bait size) in each tray were recorded and distribution patterns constructed from these data. General observations and outcomes are presented.

Smaller bait fragments: are they effective?

Location: Laboratory trial, Waite Campus, SA

Replicates: 5

Plot size: Transparent plastic 4L Decor containers containing soil from Warooka, SA to depth of 4cm, and enclosed with wire frame and stocking material

Treatments: Snail species: *T. pisana, C. virgata and C. acuta.*

Meta and Multiguard baits (2.5mm, 5mm, 7.5mm, and 10mm long)

Arenas were prepared with 30 mature snails and eight bait pieces (Meta or Multiguard). Only one snail species was tested at a time. After three days, any remaining baits were removed and weighed to determine amount consumed and snail mortality was assessed after another five days. Indicative conditions for *C. virgata* were 20°C (min19°C, max

23°C), and a relative humidity (rH) of 89 per cent (min 50 per cent, max 100 per cent). An ANOVA was performed on individual species data sets with the covariate of amount of bait consumed.

Effect of Perlka® on recruitment of snails

Location: Warooka, SA (medic and volunteer barley)

Replicates: 10

Plot size: Arena 0.2m² (circular sheet metal enclosure (15cm high) partly buried into soil with fly screen mesh fitted over top)

Treatments: Control (nil) and Perlka® (200 kg/ha) with snails added to cages at 0, 13 and 28 days after application.

On 22 May 2013, 60 cages were prepared and treated with Perlka®. Twenty adult snails *(>12mm)* each of *C. acuta* and *T. pisana* were placed in each cage to lay eggs. After 13 days, the snails were removed, mortality recorded and the cages resealed to contain any resulting juvenile snails. This was repeated in separate cages to expose snails for two weeks to Perlka® that was either freshly applied, 13 days or 28 days old on the ground. On 4 Oct 2013, all cages were assessed for juvenile recruitment and data analysed by paired t-tests. Prior to the final assessment, sheep gained access into the trial site and destroyed some arenas, thereby reducing the final replication, hence this data was not analysed.

Results and interpretation

Influence of crop and stubble on bait efficacy to control juvenile snails

The presence of stubble and/or canola significantly reduced mortality of *T. pisana* juveniles relative to the bare soil treatment ($F_{3,20}$ = 25.12, *P<0.001*) (Figure 1). In the bare soil treatment *T. pisana* mortality was 85.8 per cent, whereas in the stubble, canola plus stubble and canola alone treatments the mortality was 56.7, 44.6 and 41.1 per cent respectively. Stubble also significantly lowered the mortality from the bait treatment in the *C. acuta* experiment ($F_{3,20}$ = 6.64, *P<0.01*). In the bare soil treatment *C. acuta* mortality was 67.5 per cent, and in the stubble, canola plus stubble and canola alone treatments the mortality was 32.0, 46.5 and 52.8 per cent respectively. Clearly these results demonstrate baits do kill juvenile snails.

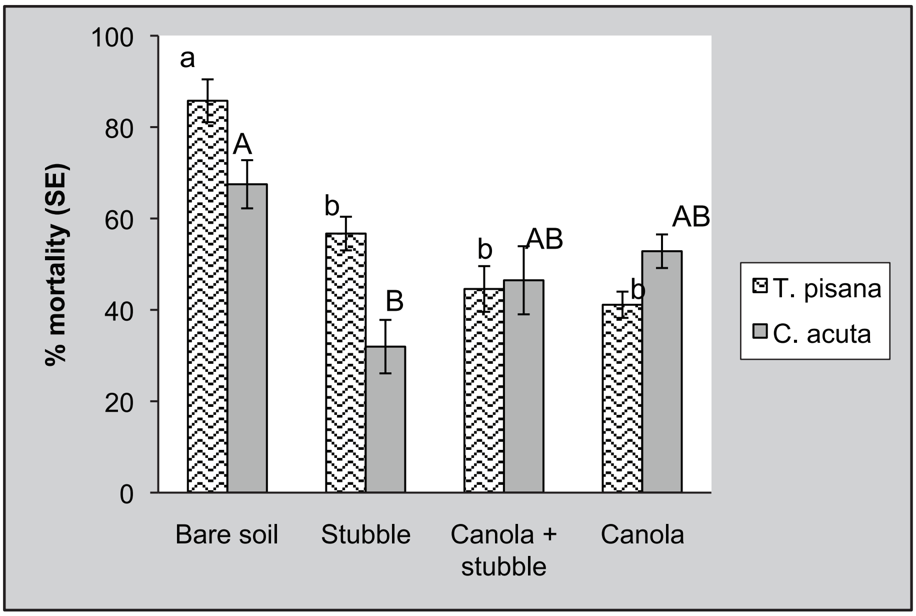

Figure 1. Mean (±SE) mortality of juvenile (2 to 3mm) *T. pisana* and *C. acuta* snails exposed to Mesurol bait in laboratory arenas containing soil with stubble and/or canola seedlings for 1 week. (Different letters of same format indicate significant differences within species, Tukey HSD test).

Canola and stubble can act as alternative food and the stubble additionally could present obstructions to these very small juveniles locating bait. While larger snails may not be so hindered by the stubble, it may still act to conceal baits and hence lessen the efficacy of the bait. Retention of stubble residues favours snails due to the more suitable habitat (G. H. Baker, 1998) and based on the results of this trial it could also reduce the effectiveness of chemical control.

Limiting alternative foods by applying baits after controlling weeds and before crop emergence are recognised methods to improve bait uptake. Additionally, the reduction of stubble prior to baiting is worth considering to increase the number of bait/snail encounters. This will be tested in 2014 field trials.

Effectiveness of spreader machinery in distributing snail/slug baits

The primary finding was that effective spread (bout) width of snail/slug bait was less than would be achieved when spreading fertiliser and differences were evident between bait products (Figure 2). Even with the best operational settings for each spreader, the spread width was consistently less than anticipated. Therefore, current bait spreader practices based on fertiliser spread widths are unlikely to be achieving the uniform spread needed for effective baiting.

Snails may not be attracted to bait and therefore consumption of bait is a numbers game, which relies on active snails encountering baits. To improve the chance of snails encountering bait, the baits must be placed uniformly and at correct rates. Based on previous work, calculations of probability of encounter as a function of number of baits, attractiveness and snail activity indicate an increased number of baits per square metre are needed. To get the most out of your baiting program, your spreader should be calibrated for bait product. A tabulated comparison of some bait products and their properties is provided at the end of this paper (Table 1).

A secondary outcome from this trial was during the spreading process where a proportion of bait was crushed into smaller fragments, dependent on product. While this increases the number of bait points on the ground, the minimum effective bait size and the degradation properties of smaller pieces means that fine crushing of baits may be detrimental to a baiting program and increase operator exposure. Further comparative results of bait size and bait density across the bout width with the tested spreaders and bait products will be presented at the 2014 GRDC Grains Research Update for Advisers in Adelaide.

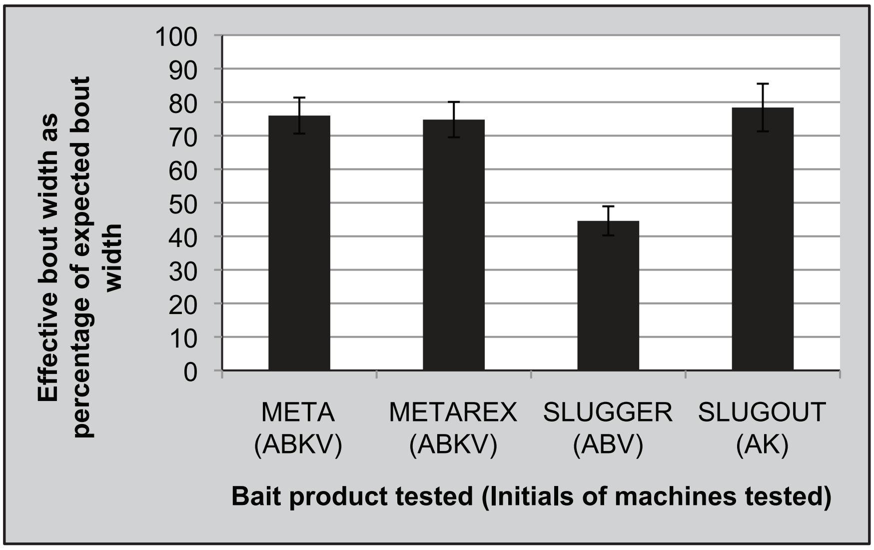

Figure 2. Effective bout width as a percentage of expected bout width (±SE) for different bait products averaged over four spreader machines (Amazone, Bogballe, Kuhn and Vicon; n=1 to 6 per machine).

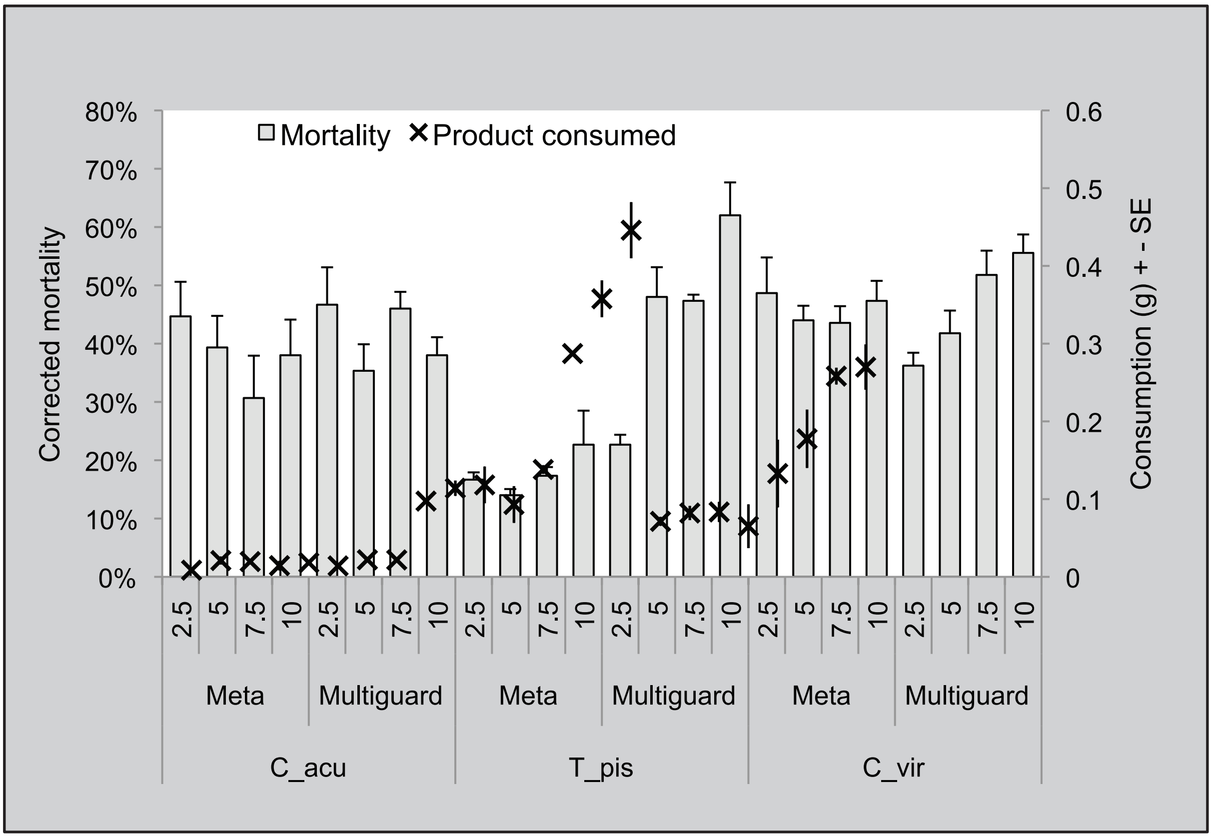

Figure 3. Average (±SE) mortality (bars) and consumption (g) of baits (X) by *C. acuta, T. pisana* and *C. virgata* adult snails exposed to Meta (1.5 per cent metaldehyde) or Multiguard (6.0 per cent Fe EDTA complex) bait pellets 2.5, 5, 7.5 or 10mm long in laboratory arenas.

Smaller bait fragments: are they effective?

Bait product and size had significant effects on mortality of round snails but not for the conical snail and consumption values indicated a deterrent effect of Meta bait (Figure 3).

The round snail, *T. pisana*, demonstrated significant differences in mortality between the two bait products (*P<0.001*) and between the bait sizes (*P<0.001*) (pooled for both products). Amount of bait eaten had a significant effect ($F_{1,31}=11.20$, $P<0.01$) on mortality, and a significant interaction between product and size ($F_{3,31}=3.47$, $P<0.05$) was evident. The Multiguard treatments exhibited a pattern which indicated that mortality in these treatments was limited by the amount of product available (i.e. bigger bait pieces = more to eat = higher mortality). The snails readily consumed all available bait and the mortality values reflected the amount of product offered. Meta bait of all sizes caused relatively low mortality, not all the bait was consumed and the amount consumed did not differ with bait size.

Cernuella virgata snails responded similarly to *T. pisana* with the exception that higher mortality occurred in the Meta treatments, however similar feeding patterns (i.e. same amount consumed independent of amount available). There were significant differences in mortality between the two bait products (*P<0.001*) and between the bait sizes (P<*0.001*) (pooled for both products). Consumption had a significant effect ($F_{1,31}=10.71$, $P<0.01$) on mortality and a significant interaction existed between product and size ($F_{3,31}=8.62, P<0.001$). This leads to the question: does the Meta product have some feeding deterrent properties towards round snails?

For *C. acuta*, no significant differences in mortality or consumption occurred between the treatments of bait product and bait size. Since *C. acuta* snails are smaller than round snails, it is unlikely that their mortality would have been limited by the amount of bait product available.

Earlier trials in 2012 indicated that bait density is more important than bait size for effective control. If bait is applied such that there is sufficient product on the ground to ensure a lethal consumption, this trial has shown that mortality will not be affected by having smaller or larger baits within the range of 2.5 to 10mm. However, different bait products or target snail species will determine the minimum lethal consumption. It is anticipated that baits smaller than 2.5mm would degrade faster and possibly be harder for snails to find especially if applied to fields with abundant stubble loads.

Effect of Perlka® on recruitment of snails

Adult snails retrieved from arenas were in very good condition with very low mortality (0.5 to 7.0 per cent) within both species. There were no significant differences in mortality between the control and Perlka™ treatments within species and time group (adult data not presented). At all dates and irrespective of the treatment, both species were observed mating and laying eggs within arenas.

Analysis of the data for the remaining arenas showed no significant difference between treatments for both species in the first two time groups (Table 2).

Earlier laboratory trials had shown that Perlka™ was 100 per cent effective in preventing *T. pisana* egg hatch at rates of 200 to 800 kg/ha (Baker & DeGraaf, 2013). Additional laboratory trials demonstrated this same effect at the lower rates of 50 to 200 kg/ha, but no effect on snail hatchling (1 to 5mm) survival exposed to 200 kg/ha Perlka™ in identical conditions. In the caged field conditions over an extended period, Perlka™ did not have a significant effect on juvenile recruitment of *C. acuta* or *T. pisana* snails, probably because the Perlka™ effect on eggs is short-term and requires eggs to be present at or very soon after the Perlka™ treatment is applied. Therefore, the usefulness of Perlka™ as a snail management tool appears very limited.

Table 2. Mean juvenile snail recruitment (snails/arena) in arenas treated with or without Perlka™, where mature snails were placed in the arenas for a two week period beginning at 0 days (immediately after application), 13 days or 28 days after the chemical treatment application. Paired t-tests within species and column indicated no significant difference

	Chemical treatment	0 days	13 days	28 days*
T. pisana	Control	58.6a	85.0a	52.5
	Perlka™	55.4a	97.0a	50.3
C. acuta	Control	22.8a	37.6a	32.5
	Perlka™	35.3a	57.6a	57.6

**Not analysed due to missing cages following damage.*

Commercial practice

'The chief obstacle to improving chemical control of slugs (and snails) is not the lack of molluscicidal materials but the difficulty of getting them into the animal' (Briggs & Henderson, 1987).

To optimise baiting programs, consider:

- modifying the ground environment to increase the likelihood of snails finding bait (i.e. reducing stubble);
- modifying the ground environment to increase the likelihood of snails eating bait (i.e. limit the alternative food options);
- applying baits at appropriate rates and even distribution (i.e. calibrate your spreader to ensure it is spreading the bait as effectively as you believe it is.); and
- taking advantage of best conditions (i.e. after rainfall when snails are active).

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Acknowledgements

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Notes

Robotics and intelligent systems for large scale agriculture

Robert Fitch and Salah Sukkarieh,
Australian Centre for Field Robotics, School of Aerospace, Mechanical and Mechatronic Engineering, University of Sydney, NSW

Keywords

agricultural robotics, autonomous systems, unmanned ground vehicles, unmanned aerial vehicles, whole-farm optimisation

Take home messages

- **Significant advances in future farm productivity will be enabled by robotics and autonomous systems.**
- **Production advances will be by a step-change in productivity through the use of many small autonomous robots that operate within a whole-farm optimisation context.**
- **The key challenge to be addressed in realising the benefits of these new technologies is to 'think beyond the robot' and develop a new logistics and information systems view of farm operations.**

Introduction

Australian food production in the 21st century is being asked to respond to significant new demands and pressures (DAFF, 2013). Although current production allows for roughly half of all food produced to be available for export, projections of massively increasing demand from Asia have prompted government to set aggressive targets for production increases. One such target is to increase exports by 45% by year 2025. Because natural resources are limited, achieving such goals must involve increasing the efficiency of production while at the same time engaging in environmental stewardship, and contending with rising human labour costs and diminishing availability of human labour.

Established trends in mechanisation for farming seek increased productivity through ever-larger tractors and implements, and in the last decade, through the use of GPS guidance technology to restrict vehicle impact to precisely defined tracks. The downside of increased vehicle size is that the associated increased weight leads to long-lasting damage to soil structure. The soil under the precisely guided tracks becomes hyper-compacted, leading to substantial and long lasting loss of land productivity.

Concurrently, the number of people involved in agriculture has been in steady decline for the last four decades (Australian Bureau of Statistics, 2012). The number of farmers in Australia has dropped by 40% since 1981. This decrease is due in part to the reluctance of young people to remain in family farms. Worse, nearly one quarter of farmers are at or above retirement age.

In order to increase its competitive position, Australian agriculture and horticulture are beginning to invest heavily in mechanisation and automation through robotics. One of the leaders of Australian agricultural robotics research is the Australian Centre for Field Robotics (ACFR) at The University of Sydney. The Centre is recognised as one of the largest field robotics groups in the world and one of the largest robotics research organisations. We conduct basic and applied research using both ground robots and aerial robots that is helping to shape the future of farm mechanisation. In this short paper, we briefly describe our current work that addresses weed maintenance and crop intelligence. We also discuss the broader role of robotics in an operational context.

Ground robots for weed maintenance and crop intelligence

The drawbacks of increasingly large tractors are evident in zero-tillage agriculture. We are involved in a collaborative project with Queensland University of Technology (QUT) and Bendee farm in Emerald, Qld to address these drawbacks through robotics (SwarmFarm, 2013). In this project, we are creating a new robotic vehicle technology that replaces a single large soil-compacting vehicle with many small vehicles that move lightly across the surface without compacting the soil or disturbing its protective top layer. The core challenge is to develop the intelligent robotic technology that will enable a single operator to manage a team of small vehicles, rather than a single large vehicle. We are demonstrating the capability and benefits of this new robotic technology in its application to weed eradication in broadacre agriculture on 4000 hectares at Bendee farm (Queensland Country Life, 2013). Our prototype robot platform is shown in Fig. 1 (left).

Another important application of agricultural robotics is crop intelligence, where robots are used to perform autonomous farm surveillance (mapping,

Figure 1. Small autonomous robot for zero-tillage agriculture (left), two ground robots and one aerial robot for crop surveillance in tree-crop applications (right).

classification, detection) and autonomously gather valuable information about crop growth and health. We are working in collaboration with Horticulture Australia Ltd (HAL) to demonstrate the capability of robots in tree crop applications such as almonds and apples, and also in the vegetable industry. Figure 1 (right) shows two ground robots and one aerial robot used in this work. These ideas could also be applied to broadacre agriculture, possibly in combination with weed maintenance. The value of crop intelligence lies in its ability to provide timely and accurate information, such as real-time yield estimates, to support management decisions.

Aerial robots for weed detection and maintenance

Another approach to counter the drawbacks of large tractors is to employ small aerial robots equipped with sensors. Although large manned aircraft may be cost prohibitive for routine information gathering, small autonomous platforms have strong potential. We have completed several projects where we developed and demonstrated aerial robotic systems for weed maintenance in an environmental monitoring context, including aquatic weeds such as alligator weed (with Land and Water Australia), and larger woody weeds such as prickly acacia (with Meat and Livestock Australia). In these projects, the idea is to locate sparse concentrations of weeds that exist in large areas, and then to deploy the herbicide locally and in a targeted manner. Weeds are automatically identified using classification algorithms that operate on visual imagery collected by the aerial robots. Herbicide can then be delivered manually or via a specially equipped robot. In the broadacre context, this type of approach can complement ground robot systems by rapidly finding concentrations of problem weeds that can then be efficiently targeted by the ground robots on an as-needed basis.

Whole-farm optimisation

Although the projects we have described, as well as others worldwide, are focussed on addressing the fundamental capabilities of isolated farm robots, the role of robots in a whole-farm context remains an open question. How will such robots be used operationally, and to what benefit? Answering this question requires a whole-farm optimisation approach. Crop intelligence and weed maintenance must be considered along with other farm operations, such as autonomous harvesting. The farm of the future will not simply replace manual operation with autonomous operation, as is the case with GPS-guided tractors, but instead will adopt a systems view that coordinates all activities. Whole-farm optimisation can be seen as 'thinking beyond the robot' to restructure farm operations in terms of the timing and logistics of all activities, and in terms of information systems where individual crop elements have a 'personality' that is accurately tracked over the crop lifecycle. The ACFR has a long history of working in large-scale operations and optimisation within defence (BAE Systems, US Air Force, Ministry of Defence UK, DSTO), mining (Rio Tinto, BHP), and commercial aviation (Qantas, Airways NZ), and we are now beginning to apply the successful methodologies developed as part of this work in the agriculture domain for more efficient operations and production systems. This whole-farm optimisation approach is where we see the greatest benefit to broadacre farming.

Summary

Significant advances in future farm productivity will be enabled by robotics and autonomous systems. The incremental gains provided by monolithic tractors and implements with add-on automation such as GPS guidance will be replaced by a step-change in productivity through the use of many small autonomous robots that operate within a whole-farm optimisation context. We have described several current projects that demonstrate ground and aerial robots performing two initial applications of agricultural robots: weed maintenance and crop intelligence. The key challenge to be addressed in realising the benefits of these new technologies is to 'think beyond the robot' and develop a new logistics and information systems view of farm operations.

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SwarmFarm. (2013). From http://swarmfarm.com

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Are you happy? Identifying the why in you

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Keywords

wellness, happiness, resilience, strategies for change

Take home messages

- **Know and play to your strengths;**
- **get your thinking right;**
- **invest in yourself; and**
- **it's all about choices.**

My client gave me one of those knowing smiles that I usually get from people when they discover my passion for the Melbourne Football Club. "I don't have the time for that Dennis," was her knowing response. We were coming to the end of our 45 minute session and I had been listening to all of the challenges that this intelligent, active person had been disclosing to me. She had been discussing all of her challenges and her sense of being overwhelmed with life.

I had asked her the two questions that I ask all people to think about: "Why do you what you do?" and "Are you happy?" It was in response to the last question that I got the response, "I don't have the time for that!"

I get what is behind the response. A sense of 'ground hog day', a sense of being influenced by so many things that she and her family business couldn't control – the weather, supply issues, other people's behaviour.

However, my reason for asking was that the conversations I have with people who identify themselves as 'happy' are very different to those I have with people who struggle with a response. The conversations with people who are happy are much more focused and driven, with action plans about how to maintain the energy, drive and results. My conversations with people who struggle to answer this question are more about strategies to become unstuck and move on.

Guess which is the better conversation to have?

So I ask you the question, "Are you happy?"

It's a question that you have to answer as an individual, a family, a team, a business and as a community.

The results are indicating that maybe many of us are unhappy and the implications are starting to hurt.

A **Safe Work Australia** report found overwork and stress costs Australia **A$30 billion a year – half the total workplace injury bill.**

An **Econtech report in 2007** found that stress-related ‘absenteeism’ and ‘presenteeism’ (where people are present in their roles but not engaged) directly costs Australian employers **A$10.1 billion** annually. These figures do not include the hidden costs of recruitment and re-skilling resulting from staff turnover.

Another study by Compsych indicated that **29 per cent** of employees come to work five or more days per year too stressed to be effective.

A bigger issue of this lack of happiness is the impact on the national health bill. **$377 million** is the annual direct health care cost attributable to physical inactivity per year, of which **$56m** is directly attributable to depressive disorders. Depression, diabetes, heart disease and hypertension are estimated to account for 44 per cent of overall productivity loss.

Of 300,000 Workhealth checks delivered in Victoria, more than **66 per cent** of participants were found to have a medium to high risk of developing type 2 diabetes and or cardiovascular disease. In addition, **92.9 per cent** of workers tested were not eating enough fruit and vegetables and **70 per cent** were not doing enough exercise.

So I ask you again, “Are you happy?”

In search of happiness

What makes you happy? I work with so many people who struggle to answer this fundamental question, and if you can’t answer this, let me tell you, neither can I!

What are your strengths?

Who has heard the saying, ‘You can be anything you want to be, if you just try hard enough’ - WRONG!

If we come from a position where we (1) don’t know our strengths and (2) don’t play to them, we will never achieve that position of happiness. There is overwhelming worldwide research (Harvard Medical School, Gallup Foundation) that indicates we tend to focus on where we can improve rather than focusing on developing what we are strong at. In every culture studied the overwhelming majority of parents and teachers focus on the lowest results as they believe they deserve the most time and attention, rather than focusing on the highest results which are ignored.

Let me give you a formula (not the only one, but a very good starting point) for happiness:

Talent

(a natural way of thinking, feeling or behaving)

X

Investment

(time spent practicing, developing your skills, and building your knowledge base)

=

Strength

(the ability to consistently provide near perfect performance)

This will contribute to happiness, which will build your resilience and wellness. It’s a basic truth. You can’t be anything you want to be, but you can be a whole lot more than the person you currently believe you are.

How do you think, feel and behave?

Do you invest in yourself and take (sometimes small but continuous) steps to achieve mastery?

The brain is a marvellous thing, but we often under-utilise it. We need to believe in the power of the brain and the effect of the **reticular activating system** (RAS), (or **extrathalamic control modulatory system**). The RAS is a set of connected nuclei in the brains of vertebrates that is responsible for regulating arousal and sleep-wake transitions. As the name implies, its most influential component is the reticular formation. In simple terms, it rewards us by what we focus on. If we focus on and think, feel and behave around our strengths, we move towards happiness, i.e. pleasure.

If we focus on and think, feel and behave around our weaknesses, that is what we get – a focus on our weaknesses or pain.

Let me share a secret with you – in my life I have had pleasure and I have been in pain, and pleasure wins very time.

So, some questions for you:

- How do you think, feel and behave?
- Are you taking time to invest in yourself to build on thinking feeling and behaving in a positive strengths based manner?

The happiness conspiracy

I don't think that you can be happy just by thinking happy thoughts. It helps, but it's not sustainable. If you only think happy thoughts, you are in a delusional state. It's like me saying that this is the year for the Melbourne Demons. Just by wishing, it isn't going to happen.

So what else can we do?

Lessons Learnt Consulting has built solutions around this very issue. To achieve happiness in life, a holistic strategy needs to be embraced. We believe there are seven elements that are all about achieving personal wellness and happiness.

Values wellness

This element asks you to start developing and living action plans around the following questions:

- Are you clear on what your values are?
- What do you stand for?
- Is there consistency between your values and your behaviours?
- What is your 'personal brand'? and at the end of the day,
- What will be your legacy?

Because after all, they are all we will be remembered for.

Career wellness

This element asks you to start thinking about and developing action plans around the question: "Why do you do what you do?"

- How did you end up the role you are doing now?
- Was it by accident or was it a matter of luck?
- Are you okay with that?
- Are you using your strengths in your career?
- Are you investing in yourself by 'sharpening your saw'?
- Is the job you are doing now just filling in time or taking you somewhere?

Work is fundamental to our wellness, and we spend enough time there, so let's make it worthwhile!

Emotional wellness

This element asks you to start developing and living action plans around the following questions:

- What strategies do you have to bounce through the challenges of life and everyday living?
- Are you surviving or thriving through the challenges of life?

Financial wellness

This element asks you to start developing and living action plans around the following questions:

- Do you have a financial plan to support you? After all, your ability to have some form of life style is directly linked to your ability to pay your bills!
- Do you have default systems around you to manage your finances?
- Are you investing in memories as well as physical possessions?

Physical wellness

This element asks you to start developing and living action plans the following questions:

- Do you look after yourself at a physical level, your diet, exercise and nutrition?
- What are your habits and rituals?

Community wellness

This element asked you to start developing and living action plans around the following questions:

- Do you give back to the community through some level of volunteering?
- Do you enhance community life not only for you and family but also for others?

Connectivity wellness

This element asks you to start developing and living action plans around the following questions:

- How well are you connect to your people around you, your family, work colleagues and community?
- Who are you associating with, are they people who build you up or bring you down?

Spiritual wellness

This element asks you to start developing and living action plans around the following question:

- What do you believe in?

Let me tell you a secret – it doesn't matter what you believe in, but you have to believe in something!

Summary

Do you have a strategy across all these seven elements? Is the strategy working for you? Do you know where to start? If not let's talk.

My personal belief is that we were all put on this earth to do something. None of us are going to get out of this life alive so we should identify what that 'something' is. Once that is found, happiness and wellness follows!

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South Australia

Grains Research
UPDATE

Further Information

the RUST BUST

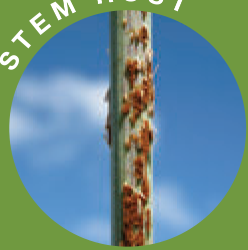
www.rustbust.com.au

Have a rust management plan this season

1. Grow varieties with adequate resistance to stem, stripe and leaf rust.
2. Phase out very susceptible (VS) or susceptible (S) varieties from your rotation.
3. Remove the green bridge (volunteer plants) four weeks prior to sowing.
4. Know the seedling and adult rust resistance characteristics of your varieties, and identify whether they require fungicide support.
5. Monitor your crop – early detection and management is best.
6. Use appropriate fungicide support to maximise crop performance and minimise disease build-up in your crop.
7. Report and/or submit suspected rust infections to the Australian Cereal Rust Survey, Private Bag 4011, Narellan NSW 2567

LEAF RUST

STEM RUST



STRIPE RUST

"If you spot rust in your crop - be proactive and tell your neighbour"

The Rust Bust is an initiative of the Australian Cereal Rust Control Program Consultative Committee, with support from the Grains Research and Development Corporation.

GRDC Grains Research & Development Corporation

Australian Cereal Rust Control Program

Sustainable management of insect pests in grain crops

Is the insect a pest or beneficial? Is control action economic / warranted? When is action needed? What should be considered when determining control options? Could management have avoided the problem?

Advisers and growers are invited to participate in a GRDC supported workshop on insect management in grain crops

Topics include:

- Implementing an integrated approach to insect management and associated decision making process
- Monitoring, record keeping and economic thresholds
- Integrated pest management tools including cultural control, conserving beneficial insects & 'softer' or more 'selective' insecticide options
- Key pest ecology and management strategies for regionally important crops

The morning session at all workshops will be indoors. The after lunch sessions at some workshops (Pittsworth, Goondiwindi, Casino, Grafton & Horsham) will be in the field (weather permitting) to discuss practical aspects of pest identification, scouting and management.

Workshops discussions will be led by extension and research staff from Queensland DAFF, NSWDPI, cesar and SARDI and facilitated by John Cameron (ICAN). Please come dressed suitably for in-field activities (weather permitting). Catering is provided.

Workshop dates and details.

- **31st March - Kadina, SA** (Farm Shed) 8:30am – 1:30pm
- **1st April - Kapunda, SA** (Golf Club) 8:30am – 1:30pm
- **8th April - Albury, NSW** (Commercial Club) 8:30am – 1:30pm
- **9th April - Bendigo, Vic** (Barclay on View) 8:30am – 1:30pm
- **10th April - Horsham, Vic** (Grains Innovation Park) 8:30am – 3:00pm

To enable in-depth discussion on key issues, workshop numbers are limited. Book early to avoid disappointment!

Workshops are targeted at advisers and leading growers who seek an improved understanding of insects and their management to implement more sustainable insect management practices. In practice, this means:

- use of scouting techniques, appropriate to the insect population and crop being assessed,
- use of economic thresholds based on insect number, damage, crop value, crop growth stage, seasonal conditions and the cost of control,
- consideration of paddock history and farm planning in relation to pest management,
- understanding of pest ecology,
- consideration of the role and impact of beneficial insects on pest populations and
- use of softer insecticide options to maintain beneficial populations when appropriate.

Workshops will focus on pests of local significance. Participants receive access to a first class resource kit including Fact Sheets, Ute Guides course notes and presentations. Technical input for workshops run in this 'DAFF Queensland Managed project', come from: DAFF Qld, SARDI, cesar, NSWDPI and ICAN.

Cost: These GRDC supported workshops are locally sponsored by Dow AgroSciences and Syngenta. This support has enabled the cost for participation to be kept to $50 (inclusive of GST)

Note: Numbers are limited. Registrations will be closed when workshops are full.

To register, contact John Cameron or Erica McKay on 02 9482 4930 or erica@icanrural.com.au or on-line registration at http://www.icanrural.com.au

Notes

THE GRDC IN YOUR SOUTHERN REGION

KEITH PENGILLEY (CHAIR)
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As a panel, we want to hear more about what is happening in our region and the needs of our stakeholders. The new GRDC structure and operating processes will help us achieve this.

The regional location of a GRDC manager grower services and our panel support team will help the panel spend more time at events and activities in the region, while remaining in close contact with the GRDC staff in Canberra.

In addition to the 10 members of the Southern Panel and the GRDC Executive Manager, we now have 42 grower and agronomist members of the four Regional Cropping Solutions Networks. These people are spread across the region in four networks, based on rainfall zone or the use of irrigation. Two or three panel members are associated with each network.

The networks play a key role in capturing research ideas and prioritising short-term issues. This leaves more time for the panel to work on strategic investment requirements that often require longer-term strategies."

REGIONAL CROPPING SOLUTIONS NETWORKS

Bringing together a consistent approach to evaluating research priorities with a large network of growers, advisers and researchers across the region has the potential to provide a focused regional portfolio of research, development and extension investments.

The objectives of the Regional Cropping Solutions Networks are to:

1. Create and manage knowledge on grains industry issues.
2. Build regional D&E capacity among growers and advisers.
3. Proactively respond to regional industry issues in a timely manner.
4. Provide enduring links between growers, advisers and the GRDC.

Four networks have been established in the southern region, each supported by a facilitator. The networks will meet face-to-face up to three times each year.

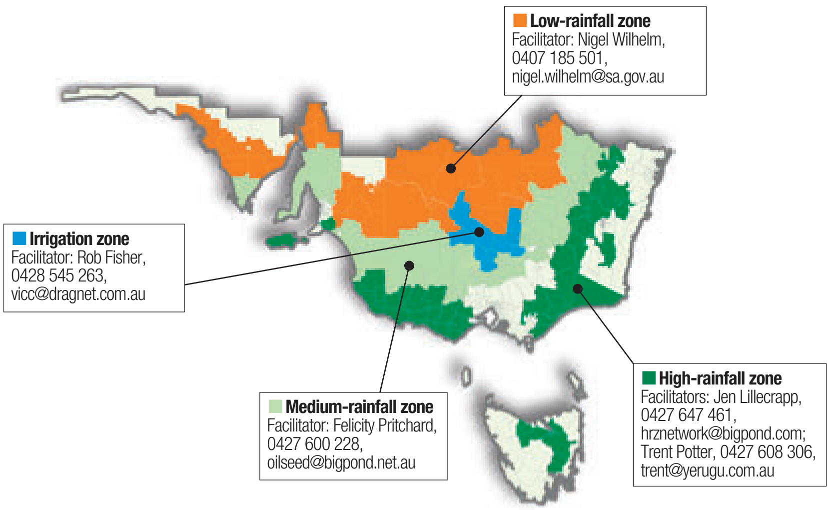
Each network will liaise with the wider grower community in their production zone, including convening regional meetings with relevant groups.

The facilitator provides each network with an effective interface with regional farming systems groups, agribusiness and research and development organisations across the regions.

While the primary focus of these facilitators will be working with farming systems groups and advisers, their work will also extend into maintaining a regional industry RD&E database of GRDC project activities and results.

Names of the members of the networks are listed on the GRDC website (www.grdc.com.au/RCSN).

GRDC Regional Cropping Solutions Networks – locations and key contacts in the southern region.



GRDC MANAGER REGIONAL GROWER SERVICES – SOUTH

As one of the three regionally based managers, Andrew Rice brings the face of the GRDC into the Southern Region. Having GRDC staff in the region offers visibility, accessibility and understanding. The skills set of the grower services manager provides another dimension to the operation of the GRDC. Andrew believes that pairing the new position of manager grower services – south, with the establishment of the facilitated Regional Cropping Solutions Networks provides the capacity and links to really make a difference.

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THE 2013-2015 GRDC SOUTHERN REGIONAL PANEL

GRDC
Grains Research & Development Corporation
Your GRDC working with you

Chair
Keith Pengilley

Keith is the general manager of a dryland and irrigated family farming operation at Conara in the northern Midlands of Tasmania, operating an 8300 hectare mixed farming operation over four properties. He is a Director of Tasmanian Agricultural Producers P/L, a grain accumulation, storage, marketing and export business.

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Deputy Chair
Dr Chris Blanchard

Chris is an Associate Professor in Food Science at Charles Sturt University's School of Biomedical Sciences in Wagga Wagga and has an Honours Degree in applied science, a PhD in molecular biology and qualifications in teaching and management. His research has included projects in genetically engineering plants, human genetic diseases, grain quality and the development of functional food ingredients.

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Neil Fettell

Based at Condobolin in the central-west of NSW, Neil is an authority on cropping and tillage systems, stubble and soil management and crop physiology. A University of New England part-time Lecturer in Crop Production, he also assists the Central West Farming Systems group and previously led grain research projects across the southern region.

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Susan Findlay Tickner

Susan is a partner in Yellow Grain Pty Ltd, an innovative and expanding dryland cropping enterprise producing cereals, pulses and oilseeds near Warracknabeal in north-west Victoria. She has a background in science communication, specialising in grains and climate research, development and extension. Susan has a Masters in Communication, a Diploma in corporate governance and is a graduate of the Australian Rural Leadership Program.

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Richard Konzag

Richard has been a grain grower at Mallala, in SA's Lower North, since 1981. He is currently cropping about 1800 hectares to wheat, durum, barley, beans, lentils, canola and oaten hay. He has served on the SA Advisory Board of Agriculture, representing the board on various forums and committees and chairing its 'Achieving an Informed and Supportive Government' working group. Richard has also served on the Plant Biosecurity CRC Grains Advisory panel since 2008.

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Bill Long

Bill is an agricultural consultant and farmer on South Australia's Yorke Peninsula. He has led and been involved in many research, development and extension programs and was one of the founding members of the Yorke Peninsula Alkaline Soils Group and chairman of the Ag Excellence Alliance. He has a strong interest and involvement in farm business management and communication programs within GRDC. He is a Churchill fellow.

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Geoff McLeod

Geoff runs an irrigated cropping farm near Finley in southern NSW. The farm produces a range of winter cereal, oilseed and grain legume crops and soybeans using both overhead and surface irrigation systems. Geoff has a degree in Agricultural Science and 30 years experience with irrigated and dryland farming systems in southern Australia. Geoff is a board member of SoyAustralia and chairman of Southern Growers, a local grower group in the southern Riverina. Geoff also provides consultancy services to government, industry and catchment management authorities related to land and water management.

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John Minogue

John runs a mixed broadacre farming business and an agricultural consultancy, Agriculture and General Consulting, at Barmedman in south-west NSW. John is the chairman of the district council of the NSW Farmers Association, Deputy Chair of the Lachlan Catchment Management Authority and a winner of the Central West Conservation Farmer of the Year award.

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Rob Sonogan

From Swan Hill in north-west Victoria, Rob is an extension agronomist who has specialised within government agencies in the areas of soil conservation, resource conservation and dryland farming systems. Over some three decades he has been privileged to have had access to many farmers, businesses, consultants, rural industry and agribusiness advisers. Rob also has been closely involved in rural recovery and emergency response into issues as diverse as locusts, fire, mice, flood and drought. Rob is currently employed part-time within the Mallee consultancy group AGRIvision.

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Mark Stanley

Mark has had extensive experience in field crops development and extension and more recently in natural resources management with the State and Commonwealth Governments and with industry. He has led a number of extension programs including the introduction of canola in SA and the national TOPCROP program. He currently operates his own project management business, Regional Connections, on the Eyre Peninsula of South Australia. Mark is the executive officer with the Ag Excellence Alliance, supporting farming systems groups across SA, and is also on the board of the Eyre Peninsula Agricultural Research Foundation. He is a committee member of the Lower Eyre Agricultural Development Association.

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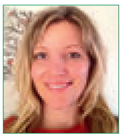
E mark@regionalconnections.com.au

Stuart Kearns

Stuart joined the GRDC in 1998 as the Northern Panel Officer and has worked in a number of roles throughout the organisation since then. He is currently the Executive Manager Regional Grower Services. The aim of the Regional Grower Services Business Group is to deliver new, innovative, high-value and improved regionally relevant products and services that meet the needs of growers and their advisers.

T 02 6166 4500
E stuart.kearns@grdc.com.au

Southern Panel Support
Belinda Cay (nee Barr)



Belinda and the Raising the Barr (RTB) team are a communication company that design creative science education programs and corporate exhibits, plus offer media, marketing, facilitation and communication services. She has a Bachelor of Science (Honours) and a Graduate Diploma in Scientific Communication. RTB provides panel support services to the Southern Regional Panel.

M 0423 295 576
E belindacay@baonline.com.au

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WE LOVE TO GET YOUR FEEDBACK

For your convenience, an electronic copy of the evaluation form has been created and can be accessed via the QR code provided or by typing the URL address into your internet browser.

To make the process as easy as possible, please follow these points:

- It must be completed on the one device (i.e. don't swap between your iPad and Smartphone devices, information will be lost).
- Once you start the survey, others should not use your device to complete their survey (i.e. one person per device).
- Make sure you click "Next" before exiting the survey to save the responses
- This survey allows respondents to start and stop the survey whenever they choose. For example, after the morning session you could complete that session's relevant questions and then re-access the survey following the afternoon session.

Thank you for your feedback.

ORM COMMUNICATIONS

https://www.surveymonkey.com/s/GRDCAdelaide

GRDC
Grains Research & Development Corporation
Your GRDC working with you

Grains Research UPDATE

GRDC Adviser Update - SA 2014

❶ **Which of these best describes your main role?** *(circle)*

1 Government Adviser
2 Government Researcher
3 Agribusiness Agronomist
4 Agribusiness Sales/Administration
5 Agribusiness R & D
6 Private Consultant
7 Grain Marketing
8 Environment/ Catchment Management
9 Farmer
10 Other (specify)...

❷ **How many years experience have you had in this role?**

.... Years

❸ **Which other Grains Research Updates have you attended?** *(circle)*

2013 2012 2011 2010 2009 2008

❹ **From the list below of the highly rated topics from the 2013 SA GRDC Adviser Update, please tick those that have influenced your advice in the last 12 months?**

☐ Using new ICT tools and social media to provide advice *(Pru Cook)*

☐ Blackleg resistance groups (Steve Marcroft)

☐ Indian ocean dipole and POAMA *(Peter Hayman)*

☐ Barley variety update 2013 *(Jason Eglinton)*

☐ Maintaining the best options with herbicides *(Chris Preston)*

☐ Understanding and managing herbicide resistance *(Bill Campbell)*

☐ Wheat variety research update for 2013 *(Rob Wheeler)*

☐ Pulse varieties and agronomy update *(Larn McMurray)*

☐ Slug monitoring and management *(Michael Nash)*

❺ **Organisers wonder whether you are happy with the content of the program.** *(Tick box and/or write, suggestions and comments)*

- **sensible topic selections?**

Yes ☐ **Partly** ☐ **No** ☐

....

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- **the chance to explore selected topics in-depth?**

Yes ☐ **Partly** ☐ **No** ☐

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- **enough access to specific agronomy recommendations (including proceedings)?**

Yes ☐ **Partly** ☐ **No** ☐

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- **opportunity to attend issues of greatest interest?**

Yes ☐ **Partly** ☐ **No** ☐

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- **intellectual stimulation?**

Yes ☐ **Partly** ☐ **No** ☐

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Please indicate any other issues you noted

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....

❻ **What is the likelihood that you will use three pieces of information from this conference in your business?**

Rate on 0 – 100% likelihood scale where 0% = completely unlikely and 100% = totally likely __________%

❼ **What is the likelihood that you will attend an Update like this next year?**

Rate on a 0 –100% likelihood scale where 0 = totally unlikely, and 100% = totally likely _________%

❽ **Would you agree with the Updates providing only electronic proceedings in 2015 (i.e. no hard copy)?** **Yes** ☐ **No** ☐ **Not yet** ☐

❾ **Please rate your degree of satisfaction with the following** *(tick)*

	1 very poor	2 poor	3 average	4 good	5 excellent
Overall program	☐	☐	☐	☐	☐
Proceedings	☐	☐	☐	☐	☐
New Release Booklet	☐	☐	☐	☐	☐
Venue	☐	☐	☐	☐	☐
Visual aids	☐	☐	☐	☐	☐
Audio	☐	☐	☐	☐	☐
Meals	☐	☐	☐	☐	☐
Organisation	☐	☐	☐	☐	☐
Registration	☐	☐	☐	☐	☐

❿ **Please make any extra comments on anything organizers can do to deliver a better conference for you.**

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⓫ **Perhaps you have been to a conference where you experienced something you really liked that could be adapted for these Updates. What was that?**

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⓬ Program content

For each presentation you attended, please rate on a scale of 0 to 10 (where 0 = totally dull and 10 = outstanding) the content of the presentation and how it was presented by placing a number in each box.
If you didn't see that presentation, leave the boxes blank. Your comments are encouraged

DAY 1 – Tuesday

	Content	Presentation	/10 Comments
Strategies and tactics to extend whole farm water use efficiency - *James Hunt*	☐	☐	....
Retaining and developing pesticide options for you and your clients - *Ken Young*	☐	☐	....
Maintaining market access – keeping it clean - *Tony Russell*	☐	☐	....

CONCURRENT SESSIONS

	Content	Presentation	/10 Comments
Getting the best from barley – agronomy and management - *Kenton Porker*	☐	☐	....
To windrow or not to windrow in 2014? - *Maurie Street*	☐	☐	....
Exploring herbicide tolerance in lentils - *Chris Davey*	☐	☐	....
Pulse check – varieties, agronomy & disease update - *Michael Lines*	☐	☐	
- *Jenny Davidson*	☐	☐	....
Plant growth regulators in broad acre crops - *Tina Acuna*	☐	☐	....
Modernisation of China's food industry - *Stephen Radeski*	☐	☐	....

Blackleg pod infection, resistance group monitoring and sclerotinia
- *Steve Marcroft* ☐ ☐ ....

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LUNCH

Maintaining flexibility and options with pre-emergents - *Chris Preston* ☐ ☐ ....

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Slug management practices – what is working? - *Jon Midwood* ☐ ☐ ....

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Maximising the nitrogen benefits of rhizobial inoculation - *Maarten Ryder* ☐ ☐ ....

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Is social media working for you? - *Pru Cook* ☐ ☐

- *Emma Leonard* ☐ ☐ ....

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New canola varieties for 2014 & retained seed study - *Trent Potter* ☐ ☐

- *Andrew Ware* ☐ ☐ ....

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FINAL SESSION

Evolution of herbicide resistance in Barley grass - *Lovreet Shergill* ☐ ☐ ....

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The competitive position of Australian grains in SE Asian markets
- *Soon-Bin Neoh* ☐ ☐ ....

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DAY 2 – Wednesday

	Content	Presentation	/10 Comments

CONCURRENT SESSIONS

	Content	Presentation	Comments
Barley variety update 2014 - *Jason Eglinton*	☐	☐	....
....			
Do we need to revisit potassium? - *Rob Norton*	☐	☐	....
....			
Cereal disease update – South Australia 2014 - *Hugh Wallwork*	☐	☐	
- *Marg Evans*	☐	☐	....
....			
Wheat variety research update for 2014 - *Rob Wheeler*	☐	☐	....
....			
Controlling herbicide resistant radish with herbicides in WA - *Grant Thompson*	☐	☐	....
....			
To guess, to probe or to model soil water - *Harm van Rees*	☐	☐	....
....			
Biopesticides – fresh hope for the future - *Gavin Ash*	☐	☐	....
....			
Opportunities with liquid systems - *Peter Burgess*	☐	☐	
- *Alan McKay*	☐	☐	....
....			
Seamless prediction – environmental intelligence for today - *Darren Ray*	☐	☐	....
....			
Increasing agricultural production by alleviating soil constraints	☐	☐	
- *Dave Davenport* - *Roger Groocock*	☐	☐	....
....			

	Content	Presentation	/10 Comments
Refining snail chemical control - *Greg Baker*	☐	☐	....

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FINAL SESSION

Robotics and intelligent systems for large scale agriculture - *Salah Sukkarieh*	☐	☐	....

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Are you happy? Identify the why in you - *Dennis Hoiberg*	☐	☐	....

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Please place this evaluation form in the return boxes located at the registration desk or mail back to ORM, PO Box 189, Bendigo 3552

Thank you for your feedback which will be evaluated and utilised to help improve future programs.