Foreword

Dear Readers

As active grain growers, the UGH board members all fully appreciate the difficulties that growers have endured over the last twelve months with drought conditions dominating in many parts of Australia. What has become increasingly obvious is that the effects of adverse cropping conditions can be minimised by growers who apply some of the new farming techniques that are being developed by groups such as the Minnipa Research Foundation and the EP Farming Systems project.

As most southern Australian grain growers would be aware, UGH is the "growers own" company - owned by growers for the benefit of growers. Our primary function is to maintain an effective controlling interest in AusBulk Ltd for the benefit of our grain grower shareholders. To support this function, UGH is also committed to using our resources to develop and improve the grain industry in a number of different areas.

One of the mechanisms for supporting the grain industry we have adopted is the establishment of partnerships with various farming systems groups. Our sponsorship of the technology transfer program undertaken by the Minnipa Research Foundation and the EP Farming Systems project is the largest sponsorship agreement that the Company has entered into to date. With several similar agreements in place with other farming systems groups, our intention has been to ensure that our support is targeted specifically at communicating to the wider grower community on new ways to help improve production outcomes and yields.

UGH is also taking a leadership role in the national grains industry. Many growers across Australia would have now heard of the Kronos Report, Review of the structural issues in the Australian grain market, that we jointly commissioned with NETCO Cooperative Ltd - the peak cooperative body representing 10 leading grain cooperatives in NSW, Victoria, WA and Queensland. This report, released in Canberra in November 2002, has assisted with the debate around Australia about the current structure and direction of the grains industry. While there is still much discussion yet to occur, UGH is committed to providing comprehensive information for all industry stakeholders in an effort to stimulate more informed reviews of our industry.

One of the other roles that UGH has adopted is in the area of educating our shareholders on their shares and the benefit and value they should strive to achieve from their investments. To this end, UGH initiated a statewide shares education program in 2002. We joined with Partners in Grain and FarmBis to deliver a series of workshops with the aim of enabling growers to fully understand the potential and value of their share investments in the grain industry.

UGH's mission is to lead our stakeholders through this evolutionary phase of the grains industry. We have sought to do this through various initiatives some of which are outlined above. In a practical sense though, one of the primary functions that we have achieved is to assist growers to benefit from the developments that farm systems groups like the Minnipa Research Foundation and the EP Farming Systems project uncover through their dedicated work. With this in mind UGH is particularly proud to support the publication of this book on behalf of the Minnipa Research Foundation and the EP Farming Systems project.

Ken Schaefer

Chairman

United Grower Holdings Ltd

Eyre Peninsula Farming Systems 2002 Summary

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All articles submitted are reviewed by the editorial team prior to publication for scientific merit and to improve readability, if necessary, for a farmer audience.

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About this manual

Greetings folks

Once again we arrive in your mailbox in March with the latest and greatest from the Eyre Peninsula agricultural research program.

We gratefully acknowledge the amazing support we have had from United Grower Holdings Ltd (UGH) who sponsor this publication, our newsletters and regularly attend the Minnipa Ag Centre Field Day. This is the second year that UGH, through the Minnipa Research Foundation, have sponsored the Eyre Peninsula Farming Systems project communication package. It is largely due to UGH's generosity that the results from our work on the Peninsula are available to all farmers on the EP and other advisers, researchers and farmers around Australia.

Despite being an absolute shocker of a season for many areas around Australia, most areas of the west coast seemed to come out of it relatively well. Out of more than 150 trials across upper, central and eastern EP, only one site didn't produce enough grain to reap from lack of rainfall.

Highlights from the 2002 season included the inaugural Minnipa Research Foundation Field Day, which in 2002 focussed on a wealth of issues related to herbicides. We've had great feedback from those who attended the day, with many people commenting that it was the best field day they had ever attended (and no, that was not from the 99% of the EP that is related to, or friends with, staff at MAC!!!!) .

The Minnipa Research Foundation are planning what they hope will be an equally fantastic day for 2003, based around nutrition issues. The tentative date is 14th August, numbers will again be limited and Foundation members will be given first option to register. Have a read of the Minnipa Research Foundation article in this book for more information on the day or becoming a member.

We've decided to leave you in peace this year and not put a survey in the back of the book! This of course doesn't mean that we don't appreciate any feedback or suggestions that you have. Feel free to give us a ring or come along to the EP Farming Systems meetings that happen across the Peninsula during February/March/April.

At these meetings we work as a group with local farmers and advisers to review the results from the previous year and thrash out the issues requiring attention in each district for the coming year. From these meetings we go away and develop work plans for the year that include research, workshops, bus trips - or whatever it may be that you require to address the issues you raised. We take these very extensive lists back to what we call the Reference Groups - two groups, eastern and western, comprised of researchers and representatives from the farmer groups and advisers from each area. These groups work out which are the highest priority issues and what we can handle given the people and resources we have to work with.

If you haven't had the chance to be involved in this process before why not give us a ring here at MAC and we can let you know what is happening where, and when.

Another quick date for your diaries this year is the Minnipa Ag Centre Field Day on 17th September 2003.

Well - good luck for 2003. Hopefully all of this working together to tackle our farming issues will one day lead to farming systems that will rely less on luck and the weather and more on the management decisions you make.

Cheers folks.

The Eyre Peninsula Farming Systems Team

Minnipa Agricultural Centre

Contents

Minnipa Research Foundation

What is it?

The Minnipa Research Foundation is the fund-raising arm of the Minnipa Agricultural Centre. The Foundation members are Paul Kaden of Cowell, John Masters of Wharminda, Rowan Ramsey of Buckleboo, Peter Kuhlmann of Mudamuckla and Samantha Doudle and Ros Fromm of MAC. The Foundation's aim is to work with MAC staff to target corporate bodies, charitable institutions and the community to provide an extra untargeted source of funds with which to initiate new areas of activities, plug gaps and use as leverage with the major funders. These funds are in turn used to support the Minnipa Agricultural Centre and the huge research and extension program it undertakes across the upper and eastern Eyre Peninsula.

2002 ACHIEVEMENTS

Sponsorship Deals

- United Grower Holdings Ltd - sponsorship of this publication and the EP Farming Systems Newsletter.
- Nufarm - sponsors of the inaugural Foundation Field Day.
- AWB Ltd - sponsors of the Minnipa Ag Centre Farming Systems Competition.
- Beeline Technologies - use of a Beeline Navigation System for the controlled traffic demonstrations on Minnipa Ag Centre.
- Burando Hill - use of 2 Haukaas Marker Arms for controlled traffic comparisons on Minnipa Ag Centre.

Field Day

The 2002 Eyre Peninsula Herbicide Diagnostic Field Day was the first annual event organised for Foundation members. The two day event was open to 'Foundation members only' on the first day (including dinner that evening) and open to everyone else (@ $100/head) on the second day, with the same program run on both days.

The Foundation is planning a similar event in 2003 with a nutrition focus. The tentative date is set for 14 of August, subject to change with seasonal conditions. Once again the day will be a mix of trials, demonstrations, guest speakers and machinery displays, all related to nutrition issues. Numbers will again be limited to ensure those attending get the most out of the day. If you want to ensure you get an invite to this event make sure your Foundation membership is up to date - or if you haven't joined yet, do it soon!

Newsletter

All members receive a Foundation newsletter twice a year, letting them know what's happening with their membership fees. Another newsletter is due out shortly after this book is finished!

HOW TO JOIN

Memberships are available to individuals ($100) OR an individual plus their spouse ($120). There is also a discounted student rate now available to students aged 16 and under ($50).

Memberships to the Minnipa Research Foundation are due annually in October and are payable at the Minnipa Agricultural Centre Field Day or via post to Minnipa Agricultural Centre.

Contact Ros Fromm at Minnipa Agricultural Centre on (08) 86805104 for a membership form today.

THANK YOU FOR SUPPORTING DRYLAND AGRICULTURAL RESEARCH

Members of the Minnipa Research Foundation

Baldock	Graeme & Heather	Kimba
Bammann	Geoff	Cleve
Bammann	Paul	Cleve
Beinke	Peter & Sue	Kimba
Berg	Dean	Kyancutta
Blumson	Bill & Deanna	Smoky Bay
Blumson	Shane & Donna	Smoky Bay
Brace	Reg & Dot	Poochera
Brace	Dion	Poochera
Breed	Nigel & Kaye	Karkoo
Bubner	Daryl	Ceduna
Butterfield	Bill	Kimba
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Dunn	Matthew	Rudall
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Fromm	Jerel	Minnipa
Fuller	Ross & Josephine	Wirrulla
Gale	Jeff & Cheryl	Ungarra
Gillett	Bob & Jan	Minnipa
Gosling	Leigh & Jenny	Lock
Guerin	Simon	Port Kenny
Guest	Terry	Salmon Gums
Guidera	Wayne	Streaky Bay
Habner	Kingsley	Port Lincoln
Hamlyn	J & D	Kimba
Hitchcock	Nathan	Lock
Hitchcock	Peter	Lock
Horgan	John & Marlene	Streaky Bay
Howard	Tim & Margaret	Ceduna
Hughes	Ben	Ceduna
Hughes	TE & JM	Ceduna
Jericho	Neville & Marcia	Minnipa
Jones	Jeff & Jodie	Arno Bay
Kaden	Paul	Cowell
Keller	Ian	Wirrabara
Kennett	Ian & Linda	Minnipa
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Koch	BJ & ML	Kimba
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Kwaterski	Robert	Minnipa
LeBrun	Dion	Tumby Bay
Lee	Howard	Streaky Bay
Longmire	Jeffery & Caroline	Lock
Lynch	Damien	Poochera
Mahar	Andrew	Ceduna
Maitland	Stephen	Kimba
Malcolm	Shane & Beth	Arno Bay
Markey	Neville & Jenny	Minnipa
Markey	Timothy	Minnipa
Masters	John	Arno Bay
Masters	Peter & Lisa	Arno Bay
May	Lyndon & Rachel	Cleve
May	Paul	Kyancutta
McBeath	Chris & Dianne	Wudinna
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Mudge	Carolyn & Darren	Streaky Bay
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Nield	Roger	Cleve
Nielsen	Peter & Pauline	Penong
Patterson	Simon	Streaky Bay
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Prime	P & D	Wharminda
Prime	A	Wharminda
Prime	C & A	Arno Bay
Ramsey	Brenton	Wudinna
Ramsey	Rowan & Teresa	Kimba
Ranford	Ben	Cleve
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Sampson	Allen & Coralie	Kimba
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Schopp	Kevin	Kyancutta
Schopp	Warrick	Wudinna
Schumann	John	Cleve
Simon	Andrew & Simon	Salmon Gums
Simpson	John & Judith	Wudinna
Siviour	Allen	Arno Bay
Story	R & S	Cowell
Stott	Allen	Ceduna
Tree	Darrell	Wudinna
Trezona	Neville	Streaky Bay
van Loon	Tim & Tracey	Warramboo
Waters	Tristan	Wudinna
Watson	Andrew & Tamsin	Wirrulla
Watson	Peter	Wirrulla
Wilkins	Gregor & Linda	Yaninee
Williams	David & Jenny	Port Neill
Williams	R & G	Kimba
Williams	Stan	Streaky Bay
Willmott	Dean	Kimba
Woolford	Bert & Barb	Kimba
Zacher	MR	Lock
Zerk	John	Lock
Zerna	Allan & Jan	Cowell
Zimmermann	Butch	Cleve

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2002 - What Happened on Eyre?

Mark Habner & Linden Masters,

Rural Solutions SA, Streaky Bay & Cleve

Western & Upper Eyre Peninsula

- Little summer rain prior to the 2002 season meant that summer weeds were not a big issue, but also meant that there was little stored moisture.
- No rainfall events sufficient to contribute to stored subsoil moisture fell until right at the beginning of seeding.
- Most districts began seeding based on patchy rain.
- Mice numbers were a concern leading into seeding; and by the end of June some paddocks were baited and resown. Worst affected areas were in close proximity to Wudinna, Streaky Bay, Ceduna and Nundroo.
- Seeding from Ceduna to Bookabie didn't commence in earnest until after June long weekend; all other districts were well into their seeding programs with some finishing by this time.
- In late July, most districts received timely rainfall which improved the outlook for the season, leading to some hope of crops holding on well if good falls came in August and September.
- Rhizoctonia patches and yellow leaf spot were the prevalent diseases in many districts.
- Rainfall in August and September was significantly less than hoped combined with numerous windy days. Areas of crop sown on shallow ground began to die off in September whilst crops in deeper soil were still hanging on.
- Mice were still of some concern leading into harvest.
- Grain weight and quality were better than anticipated.
- Stones were a bigger issue this year due to the lower crop height, with a number of loads requiring cleaning.

Eastern Eyre Peninsula

- Early in the year take-all was considered to be a major risk factor due to the absence of significant summer rainfall and good spring in 2001, providing the opportunity for significant build-up of inoculum.
- Rainfall for the month of May was average to well above average (deciles 5 to 9), but the majority of this rain fell late in the month therefore many farmers reduced their area of break crops.
- Non-wetting sands in particular proved to be difficult to manage due to below average rainfall and strong winds.
- Strong winds early in the growing season seemed to be a bit of theme for the year, resulting in smaller showers having a minor effect, and limiting opportunities for spraying.
- Crops were more reliant on growing season rainfall due to lack of subsoil moisture, and unfortunately in many cases the necessary rainfall for good yields did not come consistently.
- Rainfall in August was again well below average (ranging from 9mm at Cowell to 29mm at Cleve)
- Dry and windy conditions continued in September and October, along with a few frosts, which left few looking forward to harvest.
- Some frosted cereal crops were cut for hay to make the most of high fodder prices.
- A deluge of rain (20-75mm) fell on 25 of November causing some damage to grain by reducing test weights and there were some reports of sprouting.

Lower Eyre Peninsula

- Very little summer rain meant that stubble and pasture quality was maintained for longer than normal.
- Snail control and management was ongoing and of major concern, especially early in the year.
- When opening rain fell in May, most farmers were positive and looking forward to another good year, and crop sowing intentions remained as planned.
- Rainfall in June was well below average which had little effect on the area sown because most of LEP is normally too wet; with the exception of an area north of Tumby Bay where the lack of rain meant only small areas were sown into low moisture, very fragile sands.
- In July, crop prospects on the majority of Lower EP were considered to be excellent with rains late in the month enabling late sown crops to get some cover.
- Dry, mild and windy conditions dominated August weather, with crops beginning to show the first signs of moisture stress especially on the heavy flats and shallow stony ground.
- During October a considerable amount of hay cutting took place, including the cutting of some cereal crops, particularly on soil types deemed to deteriorate quickly with little moisture.
- During harvest it was discovered that even though the quantity was lower than average, the quality of grain was still high with low screenings and high grain weights.

Table 1: Total and growing season rainfall (mm) for selected centres across the Eyre Peninsula.

LOCATION	2002 GROWING SEASON RAINFALL	GSR DECILE	2002 TOTAL RAINFALL	ANNUAL DECILE
Streaky Bay	231	2	269	1
Penong	134	1	158	1
Ceduna	139	1	171	1
Wirrulla	151	2	186	2
Smoky Bay	176	3	224	3
Nundroo	179	3	225	3
Poochera	188	2	240	3
Minnipa	223	3	285	3
Elliston	256	1	306	1
Kyancutta	196	3	236	2
Lock	242	2	327	3
Polda Basin	221	2	301	2
Arno Bay	130	1	216	1
Buckleboo	158	2	188	2
Cleve	221	2	323	3
Cowell	124	1-2	194	2
Darke Peak	220	2	276	2
Kimba	196	3-4	237	2
Wharminda	185	2	254	2

Note: decile 5 represents approximately average rainfall.

Table 2: Production totals across Eyre Peninsula, 2002

CROP		UPPER & WESTERN EYRE		CENTRAL & EASTERN EYRE		EYRE PENINSULA - TOTAL		
		2002 season	3 year average*	2002 season	3 year average*	2002 season	3 year average*	5 year average**
Wheat	*(ha)*	308,000	295,333	365,000	379,333	815,000	823,333	792,200
	(t)	215,000	363,000	350,000	613,167	806,000	1,370,500	1,226,300
Barley	*(ha)*	70,000	63,333	110,000	111,667	265,000	264,667	245,200
	(t)	62,000	83,333	100,000	170,000	332,000	492,333	433,600
Oats	*(ha)*	38,000	37,333	1,500	6,000	41,500	45,333	48,860
	(t)	30,400	39,933	80	8,860	33,480	53,560	53,296
Triticale	*(ha)*	2,300	1,933	7,500	7,500	11,300	10,850	10,710
	(t)	2,000	2,000	5,000	11,717	10,300	17,550	16,148
Peas	*(ha)*	6,500	6,500	7,000	8,133	19,500	19,300	19,340
	(t)	4,500	6,733	2,500	8,400	11,800	22,067	21,160
Canola	*(ha)*	2,000	1,467	3,200	2,967	53,200	37,433	35,620
	(t)	1,000	1,100	1,600	2,933	50,600	50,367	46,166

** zones for recording production totals changed after 1999, therefore only 2000, 2001 and 2002 were used for 3 year averages.*

*** Total productions on Eyre Peninsula were unaffected by changes in zones.*

Understanding Trial Results and Statistics

Jim Egan,

SARDI, Port Lincoln

Interpreting and understanding replicated trial results is not always easy. We have tried to report trial results in this book in a standard format, to make interpretation easier. Trials are generally replicated (treatments repeated two or more times) so there can be confidence that the results are from the treatments applied, rather than due to some other cause such as underlying soil variation or simply chance.

The average (or mean)

The results of replicated trials are often presented as the average (or mean) for each of the replicated treatments. Using statistics, the differences between means are compared to see whether they are larger than is likely to be caused by natural variability in the trial (such as changing soil type).

The LSD test

To judge whether two or more treatments are different or not, a statistical test called the Least Significant Difference (LSD) test is used. If there is no appreciable difference found between treatments then the result shows "NS" (not significant). If the statistical test finds a significant difference, it is written as "$P<0.05$". This means there is less than 5% probability that the observed difference between treatment means occurred by chance, or we are more than 95% certain that the different results are due to the treatment effects.

The size of the LSD can then be used to compare the means. For example, in a trial with four treatments, only one treatment may be significantly different from the other three - the size of the LSD is used to see which treatments are different.

Results from a replicated trial

An example of a replicated trial of three fertiliser treatments and a control (no fertiliser), with a statistical interpretation, is shown in Table 1.

Table 1: Mean grain yields of fertiliser treatments (4 replicates per treatment)

TREATMENT	GRAIN YIELD (t/ha)
Control	1.32 a
Fertiliser 1	1.51 a,b
Fertiliser 2	1.47 a,b
Fertiliser 3	1.70 b
Significant treatment difference	P < 0.05
LSD (P=0.05)	0.33

Statistical analysis indicates that there is a fertiliser treatment effect on yields. $P < 0.05$ indicates that the probability of such differences in grain yield occurring by chance is less than 5% (1 in 20). Or in other words, it is highly likely (more than 95% probability) that the observed differences are due to the fertiliser treatments imposed.

The LSD shows that mean grain yields for individual treatments must differ by 0.33 t/ha or more, for us to accept that the treatments do have a real effect on yields. These pairwise treatment comparisons are often shown using the letter as in the last column of Table 1. Treatment means with the same letter are not significantly different from each other. The treatments that do differ significantly are those followed by different letters.

In our example, the control and fertiliser treatments 1 and 2 are the same (all followed by "a"). Despite fertilisers 1 and 2 giving apparently higher yields than control, we can't dismiss the possibility that these small differences are just due to chance variation between plots. And the three fertiliser treatments have to be accepted as giving the same yields (all followed by "b"). But fertiliser treatment 3 can be accepted as producing a yield response over the control, indicated in the table by the means not sharing the same letter.

Non-replicated trials or demonstrations

Often we are presented with results from non-replicated treatments, for example where a paddock is divided and sown to two varieties, or a strip in a paddock is left unsprayed when herbicide is applied to the rest of the paddock.

In these situations, it is not possible to make an objective (statistical) judgement of whether observed differences between treatment areas are caused by the treatments or by other factors such as soil type differences. Results from unreplicated trials or demonstrations should always be treated with scepticism, even where different treatment areas are directly adjacent. You only have to look at the yield variability on a paddock yield map to recognize how possible it is to measure different yields off adjacent strips in a paddock, without any different treatments applied to these areas.

If it is necessary to compare treatments in an unreplicated trial, take the following precautions to improve confidence that any treatment differences are real and a direct result of the treatments:

- Choose treatment areas carefully, so that they are as similar as possible (yield maps will help, if available)
- Make treatment areas to be compared as large as possible
- Treat and manage these areas similarly in all respects, except for the treatments being compared.
- If possible, place a control strip on both sides of your "treatment" strips, so that if there is a change in conditions you are likely to spot it by comparing the performance of each control to the others.
- If you can't find an area which is completely even for everything, then run your strips in a direction so that all treatments are equally exposed to the changes. For example, if there is a slope, run the strips up the slope. This means that all strips will have part of their length on the flat, part on the mid slope and part at the top of the rise. This is much better than running the strips across the slope, which may mean that your control ends up on the sandy soil at the top of the rise and your treatment on the heavy flat. This would make a direct comparison very tricky.

Grains Research & Development Corporation

It is my pleasure to welcome you to the 2002 edition of the Eyre Peninsula Farming Systems Summary. Since it began in 1999 this booklet has set the standard for timely and effective presentation of information that other groups can only follow.

Eyre Peninsula farmers are renowned as early adopters, with spray topping pastures and minimum tillage two very good examples. It is becoming clear with recent research, such as that found in this booklet, that we can only increase our water use efficiencies by first identifying and addressing the constraints imposed by our soil types. The ground-breaking fluid phosphorus and subsoil nutrition research show that productivity can leap away once these major constraints are identified and addressed.

The work outlined in this booklet goes a long way to provide a better understanding of the soil constraints and potential future management options to allow growers in the region to improve yields, productivity and farm income for the benefit of individual grain growers, communities on the Peninsula and the grains industry as a whole.

The enthusiasm of the SA government, industry and grain growers as well as Adelaide University places Eyre Peninsula Farming Systems in a position to develop a prosperous future. Along with GRDC these organisations are driving more innovative farming systems on Eyre Peninsula.

Martin Blumenthal

Program Manager Sustainable Farming Systems

GRDC

Some Useful Conversions

Area
1 ha (hectare) = 10,000 m^2 (square 100 m by 100 m)
1 acre = 0.4047 ha (1 chain (22 yards) by 10 chain)
1 ha = 2.471 acres

Mass
1 t (metric tonne) = 1,000 kg
1 imperial tonne = 1,016 kg
1 kg = 2.205 lb
1 lb = 0.454 kg

A bushel (bu) is traditionally a unit of volumetric measure defined as 8 gallons.
For grains, one bushel represents a dry mass equivalent of 8 gallons.
Wheat = 60 lb, Barley = 48 lb, Oats = 40 lb

1 bu (wheat) = 60 lb = 27.2 kg
1 bag = 3 bu = 81.6 kg (wheat)

Volume
1 L (litre) = 0.22 gallons
1 gallon = 4.55 L
1 L = 1,000 mL (millilitres)

Speed
1 km/hr = 0.62 miles/hr   10 km/hr = 6.2 miles/hr   15 km/hr = 9.3 miles/hr
10 km/hr = 167 metres/minute = 2.78 metres/second

Pressure
10 psi (pounds per sq inch) = 0.69 bar = 69 kPa (kiloPascals)
25 psi = 1.7 bar = 172 kPa

Yield
1 t/ha = 1000 kg/ha

Yield Approximations

wheat 1 t = 12 bags	1 t/ha = 5 bags/acre	1 bag/acre = 0.2 t/ha
barley 1 t = 15 bags	1 t/ha = 6.1 bags/acre	1 bag/acre = 0.16 t/ha
oats 1 t = 18 bags	1 t/ha = 7.3 bags/acre	1 bag/acre = 0.135 t/ha


Best practice


Try this yourself now


Almost ready


Searching for answers


Searching for problems

Key to symbols

Section

1

Section editor: Mark Habner

Rural Solutions SA, Streaky Bay

Field Crops Consultant

Cereals

The use of cereals on upper Eyre Peninsula is still the main income earner and mainstay of the agricultural industry. Despite season 2002 being a season with below average rainfall resulting in below average grain yields, the prices received were well above average and there was a sense that it could have been worse when compared with interstate neighbours.

The total amount of wheat grown on EP was approximately 800,000 tonnes (66% of 5 year average), 332,000 tonnes (77%) of barley, 33,000 tonnes (63%) of oats. In light of the relatively poor season, grain quality across the region was regarded as excellent, with high grain weight and protein recorded in most districts.

SARDI
SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

UNITED GROWER HOLDINGS

Managing Wheat on Wheat Rotations

Jon Hancock,

SARDI, Minnipa Agricultural Centre

Locations:
Closest towns: Minnipa
Cooperators: Minnipa Ag. Centre

Rainfall (mm)
Av. Annual total: 326 mm
Av. Growing season: 241 mm
Actual annual total 2001: 354 mm
Actual growing season 2001: 267 mm
Actual annual total 2002: 278 mm
Actual growing season 2002: 219 mm

Yield (t/ha)
2001 Potential: 3.1
2001 Actual: 2.6
2002 Potential: 2.2
2002 Actual: 0.78

Soil Type
Reddish Brown Sandy Loam

Plot size
10m x 1.6m x 4 reps

Key Messages Box

- **All wheat varieties grown in the first season yielded equally well.**
- **Excalibur and Krichauff yielded better than Frame and Yitpi in the second season regardless of previous stubble variety.**
- **The addition of nitrogen or application of fungicide to control yellow leaf spot did not improve yield , and highlights the economic risk of such inputs in this environment.**
- **The choice of variety affected profitability, through yield and grain quality payments.**

Why do the trial?

To assess the effect of wheat variety, nitrogen input and yellow leaf spot control on grain yield and quality of wheat grown in wheat on wheat sequences. This article follows on from the article in the EPFS 2001 Summary on page 16.

How was it done?

Excalibur, Frame, Krichauff, Yitpi, and Bevy rye were sown in a replicated field trial at Minnipa Agricultural Centre in 2001. Wheat was sown at 180 viable seeds/m^2, Bevy rye was sown at 40 kg/ha and 65 kg/ha of MAP (10:22:00) was applied with the seed. Plots were harvested at maturity and grain samples were analysed for protein and screenings content. Soil samples were taken prior to the subsequent sowing to assess disease carryover.

The trial was resown on the 5th of June to Excalibur, Frame, Krichauff and Yitpi in 2002 at a target density of 180 viable seeds/m^2. Each of these varieties was sown directly into the stubble of each variety grown in 2001 after the application of a Trifluralin and Glyphosate mix. 65 kg/ha of MAP was applied with the seed and 40 kg/ha of Urea was applied beneath the seed to half of the plots to evaluate the importance of nitrogen in the second year wheat. Tilt® 250 EC @ 250 ml/ha was applied to half of the plots on June 30 (tillering) for yellow leaf spot control. Plots were harvested at maturity and grain samples were analysed for protein and screenings content. Gross margins were calculated for both seasons using actual prices and the current Golden Rewards ® payment system.

What happened?

All wheat varieties grown in the first season had similar yield and protein, averaging 2.6 t/ha and 12.2% respectively, however profitability varied between the tested varieties (Table 1). The yield of Bevy rye was substantially lower at 1.8 t/ha. Screenings were affected by variety and were highest in Yitpi.

Table 1: Screenings and Gross Margin of first year (2001) wheat

	Excalibur	Frame	Krichauff	Yitpi	Rye	LSD (P=0.05)
GM 2001 ($/ha)	515	547	519	569	231	22
Screenings 2001 (%)	1.6	2.0	2.2	2.6	NA	0.3

Disease levels after the first wheat were generally low or below the detection level, however the levels of rhizoctonia and Pratylenchus neglectus posed a medium to high risk (Table 2).

Table 2: Disease risk levels after first year (2001) wheat varieties

	Excalibur	Frame	Krichauff	Yitpi	Rye
Rhizoctonia	68	102	84	101	74
RZ Risk	Medium	High	High	High	Medium
Pratylenchus neglectus	16	26	18	27	11
PN Risk	Medium	High	Medium	High	Medium

The relatively dry growing season conditions of 2002 did not cause a substantial build up of yellow leaf spot nor warrant the additional nitrogen fertiliser. Consequently, the yield of the second wheat was only affected by the choice of variety grown in the second year. Excalibur yielded more than all other varieties and Krichauff yielded more than Yitpi or Frame regardless of which variety they were sown on (Table 3). Grain protein was increased with the addition of 40 kg/ha of Urea (from 13.1% to 13.9%) and by the choice of variety (Table 3). Grain screenings averaged 4.2% and were not affected by any treatment.

The gross margin return of the second wheat variety was affected by the choice of variety in both years (Tables 3 and 4) and also by the addition of nitrogen which reduced the gross margin by $22/ha. However, because the gross margin in the first year was much greater, the small differences in return in the second year did not impact greatly on the overall return over the two years. Consequently, the average gross margin was reduced by $15 when nitrogen was applied and affected by the choice of variety in the first year (Table 4).

Table 3: Yield, protein and return of second wheat (2002).

2002 Variety	Excalibur	Frame	Krichauff	Yitpi	LSD
Yield 2002 (t/ha)	0.83	0.75	0.79	0.75	0.04
Protein 2002 (%)	13.3	13.5	13.4	13.7	0.2
GM 2002 ($/ha)	97	84	89	95	9

Table 4: Influence of the first variety on gross margin of the second variety and average gross margin over the two seasons.

2001 Variety	Excalibur	Frame	Krichauff	Yitpi	Rye	LSD
GM 2002 ($/ha)	100	84	93	87	84	10
Average GM ($/ha)	308	319	306	328	158	14

What does this mean?

In 2001, all varieties yielded equally and profitability was affected by the price received for the different grades of grain. The price differentials between ASW, APW and AH caused the return of Frame and Yitpi to be higher.

In 2002, the premium paid for AH over ASW outweighed the yield reduction of Yitpi resulting in a similar return to Excalibur or Krichauff. The smaller premium paid for APW over ASW though was not enough to offset the yield reduction of Frame and the return was reduced. Nitrogen nutrition and yellow leaf spot were not yield limiting factors and consequently the addition of nitrogen fertiliser reduced profitability.

GRDC Grains Research & Development Corporation

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Key to symbols

Location
Elliston - Nigel May
Wharminda - Peter Forrest

Rainfall
Elliston
Av. Annual total: 400 mm
Actual annual total: 428 mm
Actual growing season: 232 mm
Wharminda
Av. Annual total: 320 mm
Actual annual total: 301 mm
Actual growing season: 158 mm

Yield
Elliston
Potential: 2.44 t/ha
Average actual: 1.05 t/ha
Wharminda
Potential: 1.26 t/ha
Average actual: 0.94 t/ha

Paddock History
Elliston
2001: Pasture
2000: Euro oats
1999: Sloop barley
Wharminda
2001: Pasture
2000: Barley
1999: Pasture

Soil
Elliston: Highly calcareous loamy sand
Wharminda: Sand over sodic clay

Plot size
1.5m x 10m x 4 replicates

Other factors
Yield reduction due to moisture stress at both sites

District Wheat Variety Trials

Tim Richardson and Brian Purdie
SARDI, Port Lincoln

Why do the trials?

In response to interest from local bureau groups wheat demonstration trials were established adjacent to existing Field Crop Evaluation S4 trial sites in the traditional barley growing districts of Elliston and Wharminda. The aim of these trials was to allow farmers to observe the relative performance of new lines and cereal varieties within their area. The entries included breeder's lines, new releases and varieties widely grown in the area.

ELLISTON DISTRICT WHEAT TRIAL

How was it done?

- Treatments: varieties included eight commercial wheats, one wheat breeder's line, Gairdner barley, Bevy rye and Tahara triticale.
- Sowing date: June 6, 2002.
- Fertiliser: All varieties received 100 kg/ha of 22:15:0, drilled with the seed.
- Trace elements: Mn 400 g/ha, Zn 200 g/ha and Cu 60 g/ha.
- Herbicides: Sprayseed® @ 1 L/ha, Triflur480® @ 1 L/ha, Lve MCPA® @ 1.6 L/ha and Hoegrass® @ 1.5 L/ha, Alpha-cypermethrin @ 0.2 L/ha and Meta snail bait.
- Measurements: grain yield and quality attributes.

What happened?

After a relatively late break in the season, good follow up rains in June and July set up good yield potential. However the trial was exposed to strong and dry winds over the following months and suffered considerable moisture stress.

Table 1: Elliston District Wheat Variety Trial, 2002

Variety	Yield (t/ha)	Protein (%)	Screenings (%)	Hectolitre wt (kg/hl)	Pay Grade	Gross Income $/ha
Camm	0.92	12.9	4.3	81.9	APW	246
Frame	0.96	13.2	3.4	80.8	APW	260
H-45	1.07	11.4	7.5	81.0	APW	272
Krichauff	1.12	12.7	7.0	79.2	ASW	271
Stylet	1.01	13.1	3.7	82.4	APW	273
Westonia	1.21	11.4	14.2	79.4	Feed	255 (313)
WI99069	0.89	13.2	4.0	80.9	APW	240
Wyalkatchem	1.25	11.5	5.2	82.0	APW	323
Yitpi	0.98	12.9	5.7	80.4	AH	265
Gairdner barley	1.36	12.8	29.4	73.3	Feed	354
Tahara triticale	1.05	N/A	N/A	N/A	Feed	252
Bevy rye	0.75	N/A	N/A	N/A	Feed	N/A
Site mean	1.05	12.5	8.4	80.1		
CV (%)	5.6	2.2	29.0	0.7		
LSD (P<0.05)	0.09	0.4	3.5	0.9		

Note: Based on AWB estimated pool returns and ABB estimated silo returns delivered to Pt Lincoln

What does this mean?

The highest gross incomes were obtained from Gairdner barley and Wyalkatchem wheat which were also the highest yielding varieties. Westonia produced yields similar to Wyalkatchem but its high screening percentage reduced its classification to Feed. The reason for the high screening percentage was due to cracked rather than shrivelled grain, which was probably related to its maturity at harvest compared to other lines. There is no evidence to suggest that Westonia has a screening problem. The second value for Westonia (in brackets in Table 1) reflects the gross return calculated using a screening value similar to Wyalkatchem, assuming that the grain was cracked by harvesting rather than shrivelled. The next best varieties were Stylet, H45, Krichauff and Yitpi which produced similar returns. The poorest returns were achieved by Tahara triticale, Camm and WI99069 wheat. There were no underlying disease problems, so the individual variety yield performances reflected their ability to handle moisture stress.

WHARMINDA DISTRICT WHEAT ON SAND TRIAL

How was it done?

- Treatments: varieties included 10 commercially available wheat lines, 1 wheat breeder line, 3 barley lines, Bevy rye and Tahara triticale.
- Sowing date: June 18, 2002.
- Fertiliser: All varieties received 80 kg/ha of 18:20:0.
- Trace elements: Mn 400 g/ha, Zn 200 g/ha and Cu 60 g/ha.
- Herbicides: Touchdown® @ 0.8 L/ha, Ester800® @ 0.2 L/ha, Roundup® 1.75 L/ha, Spark® 0.075 L/ha, LVE MCPA® @ 0.8 L/ha & Alpha-cypermethrin @ 0.2 L/ha.
- Measurements: grain yield and quality attributes.

What happened?

Table 2: Wharminda District Wheat on Sand Variety Trial, 2002

Variety	Yield (t/ha)	Protein (%)	Screenings (%)	Hectolitre wt (kg/hl)	Pay Grade	Gross Income $/ha
Camm	0.89	13.4	1.0	81.8	APW	245
Excalibur	0.86	14.6	0.9	79.5	ASW	222
Frame	0.83	13.9	0.8	79.8	APW	231
H-45	0.94	13.9	1.0	81.8	APW	261
Krichauff	0.89	14.3	0.9	80.4	ASW	229
Stylet	0.90	13.9	1.9	81.2	APW	247
Trident	0.99	13.8	1.2	81.7	ASW	253
Westonia	0.93	13.7	1.6	80.2	APW	255
WI99069	0.88	13.5	0.9	81.1	APW	243
Wyalkatchem	0.87	14.3	0.7	80.8	APW	242
Yitpi	0.87	14.5	0.9	78.8	AEH	256
Barque barley	1.04	16.7	23.9	68.1	Feed	272
Gairdner barley	0.69	16.9	62.6	69.6	Feed	180
Schooner barley	1.28	16.0	42.8	70.4	Feed	334
Tahara triticale	1.03	N/A	N/A	N/A	Feed	247
Bevy rye	1.11	N/A	N/A	N/A	Feed	N/A
Site mean	0.94	14.5	10.1	78.2		
CV (%)	11.5	4.0	34.9	1.3		
LSD (P<0.05)	0.16	0.8	5.0	1.4		

Note: Based on AWB estimated pool returns and ABB estimated silo returns delivered to Pt Lincoln

What does this mean?

The season was characterised by moisture stress, which produced stunted growth and tipping in many varieties. As shown in previous years, barley clearly out yields wheat on this sand over clay soil type, especially after allowance for barley head loss suffered due to delays in harvest. The highest yielding variety was clearly Schooner, followed by Barque and Tahara triticale. Tahara triticale, with slightly better yields than all wheat varieties, provides another profitable alternative, especially for continuous cereal rotations. Although the wheat yields ranged from 0.83 t/ha to 0.99 t/ha there were no significant differences between varieties. Gairdner barley is later maturing and less adapted to seasons or environments where spring rainfall pinches off. This poor adaptation is reflected in the extremely high screenings percentage. The favourable returns from barley are due to the consistent yield advantage and the excellent current prices. However, the lower yields of wheat in this area are generally offset by the price advantage of wheat over feed barley.

Acknowledgements

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GRDC Grains Research & Development Corporation

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Cereals

Farmer wheat variety trials

Linden Masters & Mark Habner,

Rural Solutions SA, Cleve & Streaky Bay

Location
Witera - Craig & Nick Kelsh
Group: Mt Cooper Ag Bureau
Rudall - Noel & Ben Hampel
Group: Tuckey Ag Bureau
Miltalie - Peter & Robert Norris
Group: Franklin Harbor Ag Bureau

Rainfall
Witera
Av. Annual total: 350 mm
Av. Growing season: 270 mm
Actual annual total: 250 mm
Actual growing season: 225 mm
Rudall
Av. Annual total: 330 mm
Av. Growing season: 270 mm
Actual annual total: 315 mm
Actual growing season: 210 mm
Miltalie
Av. Annual total: 350 mm
Av. Growing season: 265 mm
Actual annual total: 232 mm
Actual growing season: 146 mm

Yield
Witera
Potential: 2.3 t/ha
Actual: 1.2 t/ha
Rudall
Potential: 2.0 t/ha
Actual: 1.2 t/ha
Miltalie
Potential: 0.72 t/ha
Actual: 0.5 t/ha

Paddock History
Witera
2001: Pasture
2000: Wheat
1999: Pasture
Rudall
2001: Wheat
2000: Wheat trials
1999: Wheat trials
Miltalie
2001: Pasture
2000: Frame Wheat
1999: Pasture

Soil
Witera
Major soil type description: Heavy loam
Rudall
Major soil type description: Sandy loam over clay
Miltalie
Major soil type description: Heavy loam over clay

Diseases
No disease was noticeable on all sites

Plot size
Witera
20m x 4.8m (3 replicates)
Rudall
40m x 4.8m (3 replicates)
Miltalie
40m x 4.8m (3 replicates)

Other factors
Witera
Mice, Dry conditions, Sowing date
Rudall
Dry conditions, Sowing date

Key Messages

- **Varietal selection should include a range of agronomic factors as well as local yield data.**
- **The variety Yitpi has yielded well at a number of sites over the last two seasons.**

Why do the trials?

These trials were set-up at the request of the Ag Bureaux to compare current wheat varieties with some that aren't commonly grown in the district. The Tuckey trial has been running for 5 years, with wheat being grown continuously on wheat stubble.

MT COOPER DISTRICT WHEAT TRIAL

How was it done?

Treatments: varieties included seven commercially available wheat lines

Sowing date: 24th June, 2002

Seeding rate: 80 kg/ha

Fertiliser: 18:20:00 @ 80 kg/ha

Herbicides: Trifluralin @ 800 mL/ha, MCPA + Diuron @ 500 mL/ha

Measurements: grain yield and quality attributes

What happened?

Table 1: Results from Mt Cooper Ag Bureau - District Wheat Variety Trial, 2002

Variety	Average Yield (t/ha)	Protein (%)	Screenings (%)	Hectolitre wt (kg/hl)	Pay Grade	Gross Income ($/ha)
Westonia	1.42 a	10.9 a	1.5 ab	79.4 ab	APW	383
Stylet	1.1 c	11.7 c	1.1 cd	80.7 a	APW	305
Carnamah	1.42 a	11.3 b	1.0 d	80.1 a	APW	393
WI99069	1.19 bc	11.6 bc	1.1 cd	81.2 a	APW	330
Frame	1.26 abc	11.8 bc	1.3 bc	81.7 a	APW	349
Yitpi	1.38 a	11.7 bc	1.6 a	81.3 a	AH	382
H45	1.28 ab	10.9 a	1.0 d	76.3 b	APW	347
L.S.D.(P=0.05)	0.16	0.36	0.24	3.7		

Note: Based on AWB estimated silo returns delivered to Port Lincoln as at 4 February, 2003.

What does this mean?

Westonia, Carnamah, Frame, Yitpi and H45 out performed the two new varieties of Stylet (no longer being released) and WI99069, therefore giving the higher gross incomes. All of the varieties performed well with heavy test weights, low screenings and satisfactory protein levels. There were no underlying disease problems, so the individual variety yield performances reflected their ability to handle moisture stress.

TUCKEY DISTRICT WHEAT TRIAL

How was it done?

Treatments: varieties included ten commercially available wheat lines

Sowing date: 27th June, 2002

Seeding rate: 65 kg/ha

Fertiliser: 18:20:00 @ 70 kg/ha

Herbicides: Trifluralin @ 900 mL/ha, Credit + Bonus® @ 1L/ha, Diuron + MCPA @ 300 mL/ha each

Measurements: grain yield and quality attributes

What happened?

Table 1: Results from Tuckey Ag Bureau - District Wheat Variety Trial, 2002

Variety	Yield (t/ha)	Protein (%)	Screenings (%)	Hectolitre wt (kg/hl)	Pay Grade	Gross Income ($/ha)
Westonia	1.35 a	12.9 a	2.1 a	72.9 ab	AGP	346
Stylet	1.3 a	13.6 ab	3.2 a	74.4 ab	APW	359
H45	1.3 a	13.2 ab	2.9 a	76.4 b	APW	360
Krichauff	1.2 a	13.5 ab	3.2 a	71.9 a	AGP	304
WI99069	1.2 a	13.9 ab	2.8 a	76.0 b	APW	332
Yitpi	1.2 a	13.7 ab	2.5 a	71.7 a	AGP	306
Karlgarin	1.15 a	13.0 ab	6.3 b	73.6 ab	AGP	282
Kukri	1.1 a	14.6 b	3.2 a	74.1 ab	AH	322
Spear	1.1 a	14.4 ab	3.5 a	74.3 ab	APW	302
Frame	1.1 a	14.2 ab	1.9 a	74.6 ab	APW	307
L.S.D.(P=0.05)	0.29	1.5	1.6	3.9		

Note: Based on AWB estimated silo returns delivered to Port Lincoln as at 4 February, 2003.

What does this mean?

All of the varieties in this trial had similar yields, protein, screenings and hectolitre weight. The only variety that seemed to suffer more than the other varieties from moisture stress was Karlgarin, resulting in higher screenings. The hectolitre weight was also affected by the severe moisture stress throughout the season, this affected some of the varieties when they were allocated to AGP, therefore reducing the gross income. There were no underlying disease problems, so the individual variety yield performances reflected their ability to handle moisture stress.

FRANKLIN HARBOR WHEAT TRIAL

How was it done?

Treatments: varieties included eight commercially available wheat lines

Sowing date: 25th May, 2002

Seeding rate: 60 kg/ha

Fertiliser: 18:20:00 @ 60 kg/ha

Herbicides:Sprayseed® @ 1 L/ha, MCPA @ 650 mL/ha

Measurements: grain yield and quality attributes

What happened?

After excellent sowing conditions and optimum sowing time, good early growth occurred until August when below average rainfall and severe wind events severely affected the crop potential. This moisture stress continued through most of the season. The upside of a season like this is that it gives some indication as to which varieties are better able to withstand a tight season.

What does this mean?

The relative success of Stylet in this trial is disappointing due to the fact it is no longer going to be released until the issues with rust resistance have been overcome.

The results of this trial reinforces that the impact of yield has a large impact on the gross income, and is a greater influence than pricing differences from protein and screenings. There were no underlying disease problems, so the individual variety yield performances reflected their ability to handle moisture stress.

Acknowledgements

Elders Trigg, Cleve

PIRSA RURAL SOLUTIONS

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Table 1: Results from Franklin Harbor Ag Bureau - District Wheat Variety Trial, 2002

Variety	Yield (t/ha)	Protein (%)	Screenings (%)	Hectolitre wt (kg/hl)	Pay Grade	Gross Income ($/ha)
Camm	0.49 b	15.5 a	1.5 a	75.0 ab	APW	138
H45	0.59 ab	14.6 b	7.0 b	72.2 b	AGP	144
Mulgara	0.62 ab	15.3 ab	1.6 a	76.6 a	APW	174
Stylet	0.72 a	14.4	1.4 a	75.8 ab	APW	203
Westonia	0.28 c	13.9	1.8 a	68.7 b	AGP	72
WI99069	0.57 ab	15.1 ab	0.9 a	75.3 ab	APW	161
XW207 Pioneer	0.62 ab	14.8 a	1.5 a	75.4 ab	-	-
Yitpi	0.45 bc	15.3 a	0.7 a	77.1 a	AH	135
L.S.D. (P=0.05)	0.2	0.8	3.0	3.9		

Note: Based on AWB estimated silo returns delivered to Port Lincoln as at 4 February, 2003.

Locations
Minnipa Agriculture Centre

Rainfall
Av. Annual : 326 mm
Av. G.S.R.: 241 mm
2002 total: 278 mm
2002 G.S.R.: 219 mm

Yield Potential
Wheat : 2.2 t/ha

Soil Type
Red Sandy Loam
Streaky Bay ; Bill Day

Rainfall
Av. Annual : 383 mm
Av. GSR: 309 mm
2002 total: 266 mm
2002 GSR: 225 mm

Yield Potential
Wheat : 2.3 t/ha

Soil Type
Calcareous Sandy Loam

Kimba
Alex Sampson

Rainfall
Av. Annual : 320 mm
Av. G.S.R: 247 mm
2002 total: 210 mm
2002 G.S.R: 166 mm

Yield Potential
Wheat : 1.12 t/ha

Soil Type
Red Mallee Loam

Booleroo Centre
Trevor and Wayne Rocke

Rainfall
Av. Annual : 391 mm
Av. G.S.R.: 282 mm
2002 total : 188 mm
2002 G.S.R.: 134mm

Yield Potential
Wheat : 0.80 t/ha

Soil Type
Red clay loam

Understanding Drought Tolerance in Wheat

Neil Howes[1], Shane Doudle[2], Leigh Davis[2], Rob Wheeler[1], Jim Egan[3] and Steve Jefferies [4]

[1] SARDI Adelaide, [2] SARDI Minnipa Agricultural Centre, [3] SARDI Pt Lincoln, [4] University of Adelaide

Key Messages

- **New wheat lines out-yield Frame by an average of 30% in low rainfall seasons.**
- **Confirmation in advanced trials may see a drought tolerant line released in 3 years.**

Why do the trial?

The primary motivation for this research is to explain why specific wheat varieties are consistently performing well in low rainfall areas of SA, and to aid in the early identification of new drought tolerant varieties.

In most years low rainfall or uneven distribution throughout the growing season is a major limitation to wheat yields on the Upper EP. In drought years, such as the 1999 and 2002 growing seasons, some varieties and breeding lines yielded 50-100% higher than Frame at some trial plot sites. If these higher yields could be achieved at farm scale, the negative impact of drought on the farming economy could be reduced.

Breeders, plant physiologists and agronomists do not fully understand why some wheat varieties can tolerate severe moisture stress much better than others. Numerous mechanisms have been proposed including tolerance to heat or desiccation, toxic subsoils (boron), or to root pathogens, but few of these possibilities have been rigorously tested.

A better knowledge of what characteristics are important would assist wheat breeders in producing varieties that maintain a higher yield in years of severe moisture stress, so called "drought" years.

How was it done?

Advanced breeding lines resulting from crosses of drought tolerant wheats that have performed well in the lower rainfall regions of SA were tested at Minnipa, Streaky Bay, Kimba and Booleroo in the 2002 growing season. These sites were chosen to best identify drought tolerance, based upon Biometrics SA's analysis of SARDI's Field Crop Evaluation Units (FCEU) data of trials from 1994 to 2000.

A second trial of promising lines was planted 4 weeks later at the Minnipa site only. Check varieties were Excalibur, Krichauff, Frame, Yitpi, Silverstar, Westonia and Stylet. A barley line -Mundah was also included as a high early vigour control at the early planting.

Trials were sown in 5 or 10m plots with 18cm row spacings at 180 seeds/m^2 (approx 55kg/ha) with 17:19:00 Zn5% at 75kg/ha. Some of the best performing lines from the 2001 trials were retained, and in addition 87 lines from a drought tolerance study population were examined.

Measurements of plant early vigour (plant dry weight at 8 weeks - late August), grain in main tiller and later tillers, straw weight were made on the late planted Minnipa site. At all sites a final grain weight and screenings % was measured, and the results analysed for special effects. Measurements of boron tolerance and bicarbonate tolerance were performed on some lines, while grain size, protein content and milling quality are still to be measured.

One of the highest yielding lines from last years trials (CO5642*AT01) was also included in a demonstration trial at Kalanbi managed by Ali Frischke and Leigh Davis, together with the wheat variety Mulgara (a line with high osmotic adjustment) the durum variety Tamaroi, and the triticale variety ticket.

What happened?

The 2002 growing season was probably one of the best years to measure the effects of drought tolerance. The average yields of trials at Minnipa, Booleroo and Kimba were in a narrow range of 1.2 - 1.4 t/ha considered to be the optimal range for measuring drought tolerance, where soil moisture is the major limitation to yield (Table 1).

At all sites there was severe moisture stress during September, prior to flowering, during flowering and early grain filling, with the 2nd October rain relieving stress at Minnipa for about one week. Some lines and varieties had very high screenings, showing that there was stress during most of the grain filling period.

The late planted trial had more stress prior to grain filling, lower tillering but better grain filling and lower screenings.

Table 1 : Range in yield in 2002 and long term yields at drought trial locations

TRIAL SITE	Mean Yield* t/ha (1994-2000)	Mean Yield t/ha (2002)	Range in Yield t/ha (2002)	Range in Yield t/ha (%)
Minnipa	1.55	1.44	1.11-1.60	77-112%
Streaky Bay	1.12	1.40	1.07-1.60	76-114%
Kimba	1.39	1.23	0.70-1.72	57-140%
Booleroo	1.58	1.19	0.92-1.38	77-115%

Stage 4 trial average

Excalibur and DC875-1 (a selection of RAC875) and many of the lines from the drought study population, yielded significantly higher than Frame and Silverstar

Table 2: Yield of specific lines and varieties; t/ha, (% mean) and average of 4 sites, in year 2002 drought trials

TRIAL SITE	Excalibur	DC875-1	Frame	Silverstar	Line CO5693* A036(A036)	Line CO5693*A043 (A043)	LSD ($p \leq 0.05$)
Minnipa	1.52 (106)	1.55 (108)	1.26 (88)	1.44 (100)	1.58 (110)	1.11 (77)	0.08
Streaky Bay	1.42 (101)	1.57 (111)	1.28 (91)	1.53 (109)	1.56 (111)	1.07 (76)	0.17
Kimba	1.49 (121)	1.52 (123)	0.86 (70)	1.17 (95)	1.72 (140)	1.09 (89)	0.28
Booleroo	1.22 (102)	1.21 (101)	1.29 (108)	1.10 (93)	1.23 (103)	1.11 (93)	0.22
Mean	1.41 (107)	1.46 (111)	1.17 (89)	1.31 (100)	1.52 (116)	1.09 (83)	

Table 3: Yield of specific lines and varieties ;t/ha, screenings(%), partitioning primary spike (% total grain) and harvest index (grain % of grain plus straw), Calculated biomass (t/ha) at Minnipa, 2002 drought trial

TRIAL SITE	Excalibur	DC875-1	Frame	Silverstar	Line CO5693* A036(A036)	Line CO5693* A0439A043)	Line CO5642*AT01
Grain yield	1.52	1.55	1.26	1.44	1.58	1.11	1.42
Screenings	4.3	6.6	4.1	12	4.6	3.6	10.0
Primary spike	66%	76%	80%	52%	61%	80%	86%
Harvest Index	56%	55%	49%	51%	55%	47%	50%
Maturity date	1 Nov	1 Nov	6 Nov	28 Oct	1 Nov	5 nov	4 Nov
Cal. Biomass	2.70	2.82	2.57	2.82	2.87	2.36	2.84

These lines had good early vigour, and low screenings but are not boron tolerant. The highest yielding line, A036 had the same maturity as Excalibur and DC875-1. The highest yielding lines had a harvest index of 55-56%, in contrast to the lowest yielding line, A043 (47%) and the lower yielding Frame (49%) and Silverstar (51%). The calculated biomass at harvest was also highest in the high yielding lines. Thus the higher yielding lines appeared to have both higher biomass and a higher harvest index. Mundah barley had high early vigour and this was reflected as higher grain yield (123% of mean), although it had a lower HI (46%) and very high calculated biomass (3.70 t/ha)

A number of lines that were resistant to Pratylenchus neglectus did not perform very well (with the exception being Excalibur), in contrast to 2001. Some of the early maturing lines did better at Kimba and poorer at Booleroo, but there was no effect of maturity at Minnipa in either the early or late planting.

The trial at Kalanbi suffered even more moisture stress, with yields ranging from 0.48 to 0.61 tonnes/ha. Although line CO5642*AT01 only yielded 97% and 106% of the trial means at the early and late plantings at Minnipa, it was the highest yielding in the Kalanbi trial (0.61 t/ha), exceeding Mulgara (0.58 t/ha) Ticket (0.48 t/ha) and Tamaroi (0.58 t/ha).

What does this mean?

We can be confident that the 2002 growing season was a good year to identify drought tolerant wheat lines because yields were typical of dry years but high enough to have reliable yield data. Varieties and lines (Excalibur, DC875-1) that have done well at low yielding sites in other years(1998, 1999), performed as expected, while Frame, a variety that generally performs best in high yielding sites, was towards the lower end in yield at 3 of the 4 sites.

Mundah barley did very well at all sites (average of 123% of the mean) possibly the extreme early vigour and early maturity allowing this variety to produce a very large biomass before moisture stress, and thus escape most of the drought. The study population varies in early vigour, leaf glaucousness (waxiness), maturity and boron tolerance, and Pratylenchus resistance. This year, only boron tolerance appears to have been positively correlated with yield, accounting for a 10% yield advantage. Other factors however must be involved because boron intolerant lines Excalibur and DC875-1 were also high yielding. It appears that even higher yielding lines are possible if these characteristics can be combined into one variety.

The trial at Kalanbi suffered even more moisture stress. Based on the performance of line AT01, we would expect that the high yielding A036 would have yielded considerably more than AT01, Mulgara, Ticket or Tamaroi.

The good news for farmers on the Upper EP is that these new wheat lines out-yield Frame by an average of 30% in low rainfall seasons, probably have superior leaf rust resistance and superior quality, with similar low screenings. If these characteristics are confirmed in final advanced trials and quality testing, one or more of these lines will be released within the next 3 years

Further research plans are to repeat this trial in the coming year (2003), including additional sites to improve the chances of having at least one or more low yielding "droughty" sites. Further tests for additional characteristics such as high pH tolerance, osmotic adjustment, carbon isotope discrimination and tolerance to low nutrients will be examined. We are also hybridising the highest yielding sister lines, in an attempt to combine additional favourable drought tolerance genes into one or more lines.

Acknowledgements

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Key to symbols

Matching Cereal Varieties to Soil Constraints in the Far West

Alison Frischke and Samantha Doudle,

SARDI Minnipa Agricultural Centre

Location
Penong
Bill and Laura Oats

Rainfall
Av. Annual : 318 mm
Av. G.S.R. : 215 mm
2002 annual : 213mm
2002 G.S.R. : 187 mm

Potential Yield
Wheat and Triticale : 1.54 t/ha
Barley : 1.94 t/ha

Soil Type
Red moderately calcareous sandy loam

Plot Size
13m x 1.5m x 4 reps

Other Factors
Dry conditions, mice damage, late sowing due to seasonal break

Key Messages

- **New lines of all cereals are showing promising yield advantages over current varieties where soil constraints limit yield.**
- **A two year program ensures this work will continue.**

Why do the trial?

To evaluate a range of cereal varieties, including breeding lines, for their ability to perform in difficult far west EP soils.

This work follows on from that conducted in 2002 (EP Farming Systems 2002 Summary, pg 33).

How was it done?

Trial Details: All cereals were direct drilled with superseeder points with 17:19:00 Zn 2.5% @ 75 kg/ha on 17/6/02. Standard knockdown and in-crop herbicides were applied. Varieties, lines and their attributes are shown in table 1 below. Varieties and lines were chosen to compare promising lines with current releases, or because they were not included in the S4 wheat evaluation trial alongside.

Seeding Rates: wheat @ 60 kg/ha, durum @ 65 kg/ha, triticale @ 100 kg/ha, barley @ 60 kg/ha.

Measurements: boron toxicity leaf symptoms (barley boron tolerance trial), grain yield.

Constraints: high subsoil salt and boron levels.

Table 1: Cereal varieties and lines sown at Penong, 2002.

Crop Type	Variety/line	Boron tolerance	Salt tolerance	P. neglectus resistance	P. neglectus tolerance	Maturity	Maximum Classification	Other comments
Durum	Tamaroi	I	I	MR-MS	MI	E-M	durum	Most suitable released durum
	D-263	MT	I	MR-MS	-	-	-	From Uni Adelaide breeding durum for boron tolerance research program
Wheat	Worrakatta	MT	MI/MT	MR	MT-T	E	ASW	Omitted from, or never included in S4 wheat evaluation trial
	Westonia	MT	-	MS-S	MT-T	E	APW	
	Halberd	MT	MI/MT	S	-	M	APW	
	Mulgara	MI	MI	-	-	-	APW	
	Co5236*A31	? doubtful	-	? doubtful	-	-		From SARDI/ Uni Adelaide, breeding wheat for drought tolerance research program
	Co5235*B55	T	-	? doubtful	-	-		
	Co5642*AT01	? doubtful	-	? doubtful	-	-		
	Co5642*BC05	? doubtful	-	? doubtful	-	-		
	Co5642*BG01	? doubtful	-	R	-	-		

Cereals

(Continued from page23) *Table 1: Cereal varieties and lines sown at Penong, 2002.*

Barley	Chebec	I	-	MR	MI	M	Feed	Common released varieties
	Mundah	I	-	MR-MS	I	E-M	Feed	
	Dhow (WI3102)	-	-	MS	T	M-L	Malt	Chosen as high yielding varieties from closest S4 trial (Piednippie)
	WI3586	-	-	-	-	M-L	Malt Potential	
Triticale	Tahara	T	-	R-MR	MT	M		Was the preferred variety for up to 500mm rainfall
	Tickit	T	-	MR-MS	MT	M		Most recent release – improved replacement for Tahara

Boron tolerance key: I = intolerant, MI = moderately intolerant, T = tolerant
P. neglectus resistance key: R = resistant, MR = moderately resistant, MS = moderately susceptible, S = susceptible
P. neglectus tolerance key: T = tolerant, MT = moderately tolerant, MI = moderately intolerant, I = intolerant
Maturity key: E = early, M = mid season, L = late

What happened?

All trials suffered mice damage to various degrees. Mice damage was worse on early maturing varieties, but this has not been taken into account in trial analysis.

Durum

In 2001, a very wet year for the far west, a breeding line of boron tolerant durum clearly outperformed the best standard variety, Tamaroi. In 2002, a very dry year, there was no yield difference between the salt tolerant and standard durum variety. A gene for salt tolerance is currently being introduced into this variety. Both varieties made Durum 1 grade.

Table 2: Performance of Durum, Penong 2002.

Durum Variety	Grain Yield (t/ha)	Protein (%)	Screenings (%)
Tamaroi	0.5	13.6	3.7
D-263	0.5	13.5	2.2
LSD (P=0.05)	*ns*	*ns*	*ns*

Wheat

Several lines were clearly better yielding than Worrakatta (Co5236*A31, Co5642*AT0 and Co5642*BG0), all from the Drought Tolerant Wheat Research Program. These lines were chosen from the best performers of 2001. They were not the highest performing lines in the drought tolerance research at Minnipa and Piednippie in 2002, with the best lines from that program in the dry conditions increasing yield by another 10% over the lines used in this trial (refer to 'Understanding Drought Tolerance in Wheat' article in this section). The best of these lines will be available for this trial work in 2003.

The three highest yielding varieties from the S4 wheat variety trial, located in the same paddock as the trials in this article, were RAC990 @ 1.00 t/ha, WI99107 @ 0.96 t/ha and Camm @ 0.93 t/ha.

The variety Mulgara which has an osmo-regulation gene to confer drought resistance yielded 11% below Worrakatta.

Table 3: Performance of selected wheat varieties and lines, Penong 2002

Wheat Variety	Grain Yield (t/ha)	Yield as % of Worrakatta	Protein (%)	Screenings (%)
Worrakatta	0.60	100%	13.2	2.8
**Westonia	0.23	39%	13.4	2.7
Halberd	0.53	87%	13.6	2.1
Mulgara	0.54	89%	14.1	2.0
Co5236*A31	0.72	120%	11.9	3.7
**Co5235*B55	0.52	85%	15.4	3.8
Co5642*AT01	0.69	115%	13.3	2.2
Co5642*BC05	0.59	98%	14.4	1.9
Co5642*BG01	0.71	118%	14.2	1.4
LSD (P=0.05)	*0.07*	-	*0.3*	*1.1*

***indicates severe mouse damage to this variety*

Barley

Several boron tolerant lines yielded higher than the highest yielding varieties chosen from previous S4 barley trials (WI3102 & WI3586) shown in Table 4. The best performing barley lines at the site (WI3812, WI3815, WI3816) all came from the Breeding Barley for Boron Tolerance program (Table 5). These were all at least 0.1 t/ha higher yielding than Schooner. The dry seasonal conditions meant that there were a lot of boron toxicity symptoms on the leaves, however there was no correlation between the leaf symptoms and yield in the boron barley trial (Table 5).

Table 4: Performance of selected barley varieties and lines, Penong 2002

Barley Variety	Grain Yield (t/ha)
Chebec	0.6
Mundah	0.49
WI3102	0.71
WI3586	0.74
LSD (P=0.05)	0.04

Table 5: Performance of selected barley varieties and lines from the Breeding Barley for Boron Tolerance program, Penong 2002

Barley Variety	Leaf Symptoms	Grain Yield (t/ha)
Barque	4	0.81
Keel	2.	0.29
Schooner	3	0.77
Sloop	7	0.74
WI3794	1	0.67
WI3795	2	0.72
WI3796	3	0.74
WI3797	4	0.60
WI3812	5	0.94
WI3813	3	0.82
WI3814	5	0.78
WI3815	5	0.92
WI3816	5	0.90
WI3817	3	0.70
Wi3818	5	0.77
LSD (P=0.05)		0.1

Triticale

There was no yield difference between the two triticale varieties in this trial in 2002. Triticale coped well with the dry conditions. Whiles it's gross income was less than those of the best wheats, it's role as a valuable rotational break crop would benefit future wheat crops, except where take-all is a problem.

Table 6: Triticale performance at Penong, 2002

Triticale Variety	Grain Yield (t/ha)	Protein (%)	Screenings (%)
Tahara	0.66	12.8	3.9
Tickit	0.68	12.1	3.2
LSD (P=0.05)	ns	0.15	0.4

What does this mean?

Durum is a high value crop, but still needs a lot of improvement before it is suited to low rainfall environments with hostile subsoils. The introduction of salt tolerant genes will be very beneficial towards adapting durum to these environments.

There are some very promising drought tolerant wheat lines coming through the Breeding for Drought Tolerance program. Following the 2002 drought, the state government has committed funding towards this program for the next 2 years, so be sure to keep a close eye on these trials.

Acknowledgments

We'd like to thank the Breeding Barley for Boron Tolerance, Understanding Drought Tolerance and SA Durum breeding programs for their support and provision of lines for these trials. Special thanks to Bill, Laura and Trevor Oats for hosting the trial and Wade Shepperd and Leigh Davis for technical support .

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GRDC Grains Research & Development Corporation

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Cereals

Breeding for boron tolerance in barley

Glenn McDonald[1], Jason Eglinton[1], Leigh Davis[2] and Andy Barr[3]

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Location
Minnipa Agricultural Centre

Rainfall
Av. Annual : 326 mm
Av. G.S.R.: 241 mm
2002 total: 278 mm
2002 G.S.R.: 219 mm

Yield
Potential: (wheat) 2.58 t/ha

Sowing date
20/6/02

Paddock History
2001: Wheat
2000: Pasture
1999: Wheat

Soil Type
Red sandy loam

Plot size
10mx1.6mx 5 reps

Other factors
Sowing time, dry conditions at flowering, boron toxicity

Key Messages Box

- **Introducing boron tolerance from the variety Sahara has reduced symptoms of boron toxicity and reduced boron concentrations in plant tissue, but has had little effect on yield.**
- **The lack of substantial gains in yield may be partly associated with large amounts of genetic material from Sahara still present in the boron tolerant lines.**
- **The work has developed some guidelines for future directions in breeding for boron tolerance.**

Why do the trial?

To understand why there has been limited success in improving the yield of barley after increasing boron tolerance.

Improving boron tolerance of barley is a priority of the Waite barley breeding program. The source of boron tolerance used in the breeding program is the North African landrace, Sahara, which is a tall, 6-row variety with exceptional tolerance to high soil boron. There are at least three boron tolerant genes in Sahara that contribute to boron tolerance and the boron tolerance associated with chromosomes 2H and 4H has been the basis of improved boron tolerance. When Sahara is used in crosses and the progeny selected for boron tolerance less severe visual symptoms of boron toxicity and lower concentrations of boron in the plant tissues occur, but grain yields are often no better than the lines that have less boron tolerance. The work described here follows on from that reported last year in. FS2001, p. 28

How was it done?

Two experiments were conducted at the Minnipa Agricultural Centre in 2002. Both experiments used backcross lines of Sloop and the Victorian breeder's line VB9104, both of which are boron intolerant. The lines have been selected on the basis of the presence (+) or absence (-) of the Sahara boron tolerance genes on chromosomes 2H and 4H and are designated according to this 2H/4H combination as: -/-, -/+, +/- or +/+. Therefore the -/- lines should have little boron tolerance and be similar to the parents (Sloop, VB9104), while the +/+ has both boron tolerance genes from Sahara and should show high levels of boron tolerance.

Treatments & Measurements

Experiment 1: 26 lines of Sloop and 26 lines of VB9104 were compared. The parents (Sloop and VB9104), Sahara, the barley cultivars Gairdner, Mundah, and Keel, and the wheats Schomburgk and BT Schomburgk were included as checks. Boron toxicity symptoms, maturity and grain yield were measured

Experiment 2: 10 lines of Sloop and 7 lines of VB9104 were compared with the parents, Gairdner, Mundah, Keel, Schomburgk and BT Schomburgk. Measurements of boron toxicity symptoms, maturity, dry matter and boron concentration at flowering, root distribution at flowering, soil moisture to 80 cm after emergence, at flowering and late grain filling were made.

What happened?

Boron toxicity and grain yield

Sloop was severely affected by boron toxicity and VB9104 was moderately affected, but the presence of the Sahara genes reduced boron toxicity in both backgrounds (Table 1). No visual symptoms of boron toxicity were evident on Sahara (Table 1) and the boron concentration in Sahara was less than 1/2 that of the sensitive genotypes (data not shown). The check varieties, Gairdner, Mundah and Keel showed similar levels of boron toxicity symptoms, but were all less than Sloop. Despite the large differences in visual expression of boron toxicity, none of the boron tolerant backcross lines yielded more than the parents (Table 2).

Table 1: Experiment 1: Scores of visual symptoms of boron toxicity (0-10 scale)[A] on 3 October

[A]Scale: 0 = no symptoms

	GENETIC BACKGROUND	
Genotype (2H/4H)	Sloop	VB9104
Parent	8.5	4.6
-/-	3.9	4.4
-/+	2.9	2.9
+/-	1.3	3.5
+/+	1.3	1.8
Sahara	0.0	
Gairdner	4.0	
Mundah	4.0	
Keel	4.4	
SED	1.9	

Table 2 Grain yields (t/ha) of barley and wheat genotypes showing different levels of boron tolerance

	GENETIC BACKGROUND			
Genotype	Experiment 1		Experiment 2	
	Sloop	VB9104	Sloop	VB9104
Parent	1.1	1.0	1.1	1.1
-/-	1.0	1.0	1.0	1.1
-/+	1.0	1.1	1.1	1.2
+/-	1.1	1.1	1.1	0.9
+/+	1.1	1.1	1.1	1.2
Sahara	0.8		1.0	
Gairdner	1.2		1.3	
Mundah	1.2		1.1	
Keel	1.2			
Schomburgk	0.9		1.2	
BT Schomburgk	1.1		1.1	
SED	0.15		0.11	

Root growth

All the genotypes showed similar patterns in root distribution down the profile. The greatest depth of root penetration occurred with Sahara and the boron-tolerant lines of Sloop (Table 3), but there was no evidence that improved boron tolerance substantially increased root growth in the subsoil.

Table 3: Root distribution in the soil profile at anthesis of barley genotypes showing different levels of boron tolerance.

Root growth was measured as the number of root intercepts in a 4.5cm soil core

Depth (cm)	Sloop genotype Parent	Sloop genotype +/+	VB9104 genoptye Parent	VB9104 genoptye +/+	Sahara
0–10	40±0.0	41±3.2	35±12.8	29±6.8	39±4.8
10–20	15±3.3	12±1.4	9±1.3	11±1.9	9±1.3
20–30	11±2.5	9±1.3	9±1.1	10±2.2	9±2.0
30–40	9±1.5	9±1.0	7±0.7	9±2.1	5±2.2
40–50	5±1.2	5±1.0	3±0.9	4±1.7	6±-0.5
50–60	1±0.9	1±0.6	1±0.3	2±1.2	3±0.5
60–70	0.0	0.2±0.1	0.0	0.0	1±0.5
70–80	0.0	0.0	0.0	0.0	0.0

Soil moisture extraction

No difference between boron tolerant and intolerant lines in the amount of soil moisture extracted was found. The soil moisture profiles during the year showed that all the moisture below 30 cm was effectively used by anthesis (Fig. 2) and subsoil moisture did not contribute greatly to crop water use during grain filling.

Genetic analysis

Sahara has many poor agronomic characteristics and its yield potential is low. Detailed analysis of chromosome 2H in the Sloop backcross lines has shown that there are still large amounts of the Sahara genetic material present. Much of this material is unrelated to boron tolerance and it may be limiting the yield of the boron tolerant lines.

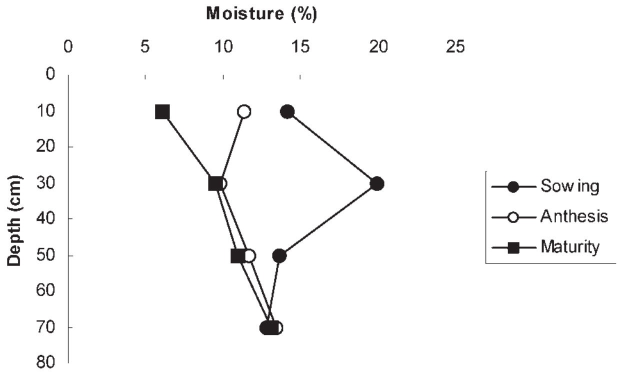

Figure 1. Average values for soil moisture in Experiment 2 in 2002

What does this mean?

The results are consistent with previous work showing little yield improvement following improvements in tolerance to boron toxicity. The work over the past two seasons has suggested why this may be so. Field data and genetic analysis provide evidence of a carryover effect of Sahara which is not related to boron tolerance, but which may be reducing the yield potential of the boron tolerant lines. Further backcrossing and selection to reduce the unwanted effect of the Sahara or using the current boron-tolerant lines as 'bridging' lines to transfer boron tolerance to lines with better agronomic characteristics may overcome this. Alternatively, sources of boron tolerance from varieties other than Sahara could be considered.

The selection of the boron tolerant lines used in this work has been based largely on molecular markers linked to the visual symptoms of boron tolerance and boron concentration in the tissue. While the marker on chromosome 2H is associated with root growth under high boron, another boron marker (on chromosome 3H) is also linked to root growth under high boron. This marker has not been transferred successfully into the barley lines developed from Sahara. More attention should to be given to the importance of this characteristic in future selection.

The advantage of improved boron tolerance to yield is strongly influenced by environment. The very dry spring in 2002 may have contributed to the lack of a response to improved boron tolerance. The highest concentrations of boron are in the subsoil and it is argued that improving root growth in the subsoil by improving boron tolerance increases the ability of crops to exploit the subsoil reserves. However, in 2002 subsoil moisture reserves were used prior to anthesis and consequently, the use of subsoil moisture during grain filling was not important to yield. This may have reduced any advantage of improved boron tolerance to improved grain growth.

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Cereals

Location
1: Minnipa
2: Pt Wakefield

Cooperators
1: MAC
2: Andrew Wilson

Rainfall
Av. Annual total
1. 326 mm
2. 190 mm
Actual growing season:
1. 219 mm
2. 143 mm

Sowing Date
1: 6/6/02
2: 14/6/02

Fertiliser
1: 75kg/ha 17:19:0 + 2.5% Zn
2: 100 kg/ha 21:14:0 + 2.5% Zn

Plot size
1: 5.0 m x 1.6 m
2: 3.2 m x 1.2 m

Yield
1: 0.74-2.24 t/Ha
2: <1 t/Ha

Barley Breeding for Low Rainfall Environments

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Key Message Box

- **ICARDA lines yielding equivalent to the best Australian feed varieties in low rainfall trials were identified**
- **Some lines have high relative yield across drought stressed and favourable environments (yield stability)**
- **These ICARDA lines represent genetically different sources of adaptation for Australian breeding programs**

Why do the trial?

Almost one third of the total area sown to barley in Australia (979,000 ha) has returned mean grain yields of only 1.41 t/ha in the period 1986-1997 (ABARE 1999). Improving the productivity of barley in the cereal growing areas of Australia requires evaluation of alternate breeding material with adaptation to low rainfall environments, since drought is a major factor limiting barley productivity. Wheat is more widely grown in the marginal cropping areas of Australia, and barley is possibly less well adapted since barley breeding in Australia has predominantly focused on improving malting quality using unadapted North American and European material. In most Mediterranean-type, dryland cropping environments of the world, barley is the crop best adapted to the marginal fringes of cropping areas.

Barley lines from ICARDA (International Centre for Agricultural Research in the Dry Areas, Syria) are being evaluated in Australian low rainfall environments since they have potential adaptation and improved yield stability, which may be incorporated into current Australian barley. These ICARDA barley lines have been bred for improved drought tolerance and adaptation to soils of low fertility from material of diverse genetic backgrounds, including wild barley and primitive landraces. Historically, Australian barley breeding programs have been involved in germplasm exchange with ICARDA, and major advances in adaptation of Australian barley has been achieved using lines from North Africa and the Middle East, which were key parents in the development of Clipper and Keel.

Field trials were conducted at four low rainfall sites in 2002 to evaluate the adaptation of various barley lines to low rainfall environments. The lines evaluated are from ICARDA and elite lines from Australian breeding programs. These experiments follow those conducted since 1999 (previously reported in the EP Farming Systems Summary FS1999 pg 15, FS2000 pg 15-16, FS2001 pg29-30), to identify new breeding lines to be used in Australian breeding programs to improve yield and yield stability in low rainfall environments.

How was it done?

In South Australia, replicated field trials were conducted at Pt. Wakefield and Minnipa Agricultural Centre (MAC) with 118 and 144 barley lines evaluated at each site respectively. The material evaluated included current varieties and breeders' lines from ICARDA and the Australian breeding programs. Field trials were also conducted on the same 144 barley lines in low rainfall sites at Ouyen (Victoria), Tara (QLD), Condobolin (NSW), and Salmon Gums (WA). Assessment was made for yield and physical grain characteristics under drought stress, a number of agronomic traits, and boron toxicity symptoms that were prevalent at Pt. Wakefield and MAC.

The ICARDA barley lines included in the 2002 trials were those having comparable yields to current Australian varieties evaluated previously under a range of environmental conditions, in field trials at Pt. Wakefield and MAC from 1999-2001. Reselections of ISBYT-LRA(C)-19, identified as having grain yield and yield stability equivalent to the best current Australian varieties, were grown in the 2002 trials.

What happened?

The 2002 season was characterised by mild terminal drought stress at MAC, and severe drought stress at the Pt Wakefield trial site. Grain yields were between 0.74 and 2.24 t/ha at MAC, and less than 1 t/ha at Pt. Wakefield. The relatively dry season minimised the development of foliar diseases, but increased the severity of boron toxicity at both trial sites. Drought stress was experienced at the four interstate trial sites, with severe drought stress making the Salmon Gums and Condobolin sites unharvestable, Ouyen yield was less than 1 t/ha, and Tara between 0.6-3.2 t/ha.

In the South Australian trials, there was a large range of grain yields for the ICARDA lines at both sites. A number of ICARDA lines yielded equivalent or higher than current feed varieties and elite breeding lines. Keel is the highest yielding commercial feed barley in these low rainfall environments, and ICARDA lines with

Table 1: The performance of several ICARDA barley lines in comparison to four current varieties evaluated over 4 seasons (1999-2002) x 2 sites (Minnipa Agricultural Centre = MAC, Port Wakefield = PTW), representing drought stressed and favourable environments. Values are grain yield expressed as a percentage of Keel (yield greater than Keel indicated in bold) at individual locations and over all drought stressed and favourable environments, with adjusted mean yield (t/ha) in parenthesis for Australian varieties.

	Drought Stressed				Favourable					
Genotype	1999		2002		2000		2001		Environments	
	MAC	PTW	MAC	PTW	MAC	PTW	MAC	PTW	Drought	Favourable
ICARDA#12	-	-	94	87	94	**107**	97	93	92	99
ICARDA#23	-	-	**106**	**107**	88	98	98	80	99	92
ICARDA#25	-	-	**104**	83	87	88	94	75	93	87
ICARDA#26	-	-	89	90	97	97	87	80	92	88
ICARDA#39	-	-	94	**101**	78	87	84	88	88	86
PARENT#2	-	-	**103**	98	78	90	88	87	92	88
PARENT#19	-	-	**111**	**101**	77	97	88	73	95	86
ISBON--LRA-M-2	71	99	84	83	82	88	88	75	83	84
ISBON--LRA-M-52	83	81	87	**100**	90	98	94	83	88	92
ISBON--LRA-M-81	95	84	85	98	85	92	83	75	88	83
ISBON--LRA-M-107	95	68	97	**110**	84	88	81	73	91	81
ISBYT-LRA(C)-4	86	81	**104**	76	92	99	97	86	92	94
ISBYT-LRA(C)-15	80	89	**106**	99	88	94	77	77	94	83
ISBYT-LRA(C)-19	83	**103**	84	81	95	**102**	94	89	89	95
ISBYT-LRA(M)-19	98	78	90	97	93	97	91	83	91	90
ISBYT-LRA(M)-22	75	74	**101**	99	82	93	94	78	88	89
Keel	(0.80)	(0.74)	(2.01)	(0.89)	(2.05)	(3.37)	(3.88)	(3.13)		
Barque	86 (0.69)	**105** (0.78)	85 (1.70)	71 (0.63)	**100** (2.06)	**102** (3.45)	81 (3.16)	82 (2.57)	90	88
Mundah	**105** (0.84)	70 (0.52)	93 (1.87)	**100** (0.89)	90 (1.84)	96 (3.24)	102 (3.97)	84 (2.63)	92	95
Schooner	85 (0.68)	**100** (0.74)	81 (1.62)	88 (0.78)	99 (2.03)	84 (2.83)	91 (3.53)	76 (2.38)	90	84
Site Mean (t/ha)	0.56	0.53	1.68	0.70	1.71	2.99	3.49	2.43	1.03	2.97
SED	0.16	0.08	0.16	0.14	0.14	0.30	0.20	0.29		
%CV	18.5	18.5	12.4	28.7	9.1	12.8	7.7	13.9		

equivalent grain yield were identified in the drought stressed environments. The ICARDA lines with high grain yield under the drought stressed environments relative to Keel, and compared to favourable environments are shown in Table 1. Most of the ICARDA lines in Table 1 show good grain yield stability, yielding relatively well in both stressed and favourable environments. The grain yield stability of these ICARDA lines will be more formally tested at a later date. Grain physical characters (screenings percentage, thousand grain weight, and test weight) are being currently assessed. Although not shown, the breeding line WI3806 derived from a Mundah/Keel/Barque cross, yielded significantly higher than Keel at MAC and equivalent at Port Wakefield, however the yield stability of this line is to be determined through further field trials.

What does this mean?

The high level of drought stress in the 2002 trials has provided useful information for identifying ICARDA lines with good general adaptation to our low rainfall environments. Combined with the 1999 low rainfall trail data, and 2000-2001 high yielding trials, we can now identify lines with high yields in both low rainfall and favourable environments indicating yield stability. Also the collection of data for other agronomic characteristics of the ICARDA lines will enable identification of the basis for their high yielding capacity in low rainfall environments. The group of ICARDA lines identified that perform well across these diverse environments, have different genetic background to current Australian breeding material, and are being used as parents in the development of better adapted low rainfall feed barley varieties.

A program of field evaluation at these six sites is planned for both the 2003 and 2004 growing seasons. Further advanced lines from the ICARDA program will be tested in addition to new Australian breeding lines. The first group of lines developed from crossing ICARDA and Australian barley will be evaluated by the SA Barley Improvement Program in yield trials in the 2003 season. This work is aimed at developing the next generation of will adapted Australian barley varieties.

Acknowledgements

The authors wish to acknowledge the assistance of Leigh Davis and Shane Doudle in the management of field trials at MAC, and the financial support of the GRDC.

GRDC Grains Research & Development Corporation

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Cereals

Nitrogen and Seeding Rates on Malting Barley - a farmer demonstration

Mark Habner and Linden Masters,

Rural Solutions SA, Streaky Bay and Cleve

Location
Michael and Angela Agars
Tooligie Hill
Murdinga Ag Bureau

Rainfall
Av. annual: 400 mm
Av. G.S.R: 275 mm
2002 total: 316 mm
2002 G.S.R.: 208 mm

Yield Potential
Barley 2.4 t/ha

Paddock History
2002: Sloop Barley
2001:Krichauff Wheat
2000: Frame Wheat
1999: Karoo Canola

Soil Type
Red loam

Plot Size
0.18 ha

Key Messages

- **Applications of urea increased grain yields in malting barley**
- **Higher seeding rates did not increase grain yield**

Why do the trial?

This trial was set up by the Murdinga Agricultural Bureau to determine how different seeding rates and urea application affected the yield and protein levels of malting barley.

How was it done?

Three different rates of urea (0, 50, 100 kg/ha) were drilled after the break of the season in May. Sloop barley was then sown at 72 kg/ha on June 2nd with a commercial air seeder. Also three different seeding rates (50, 72 or 100 kg/ha) were compared with 50 kg/ha of urea pre-drilled. A basal application of DAP (18:20:0) at 95 kg/ha was applied to all treatments. A Credit®, Bonus®, and MCPA mix, as well as Triflur 480® @ 1L/ha, were applied pre-sowing. Grain yield and quality were determined at harvest.

What Happened?

Grain yield increased slightly with increasing rates of urea, (Table 1) as did grain protein and screenings. Increasing seeding rates resulted in a small decrease in yield and an increase in grain screenings. Grain protein was also increased when 100 kg/ha of seed was used. This resulted in poorer returns at the higher seeding rates even though all treatments achieved Malting 3 quality.

Table 1: Influence of nitrogen and seeding rate on yield and grain quality of malting barley at Tooligie Hill, 2002.

Treatment	Urea Rates			Seeding Rates		
Urea kg/ha	0	50	100	50	50	50
Seeding Rate kg/ha	72	72	72	50	72	100
Yield t/ha	2.0	2.2	2.3	2.2	2.1	2.0
Protein	9.8	10.5	12.1	10.8	10.8	12.3
Screenings	12.4	16.5	24	18	20	29.3

What does this mean?

- Despite the relatively dry conditions during the 2002 season, applications of pre-drilled urea still increased grain yields on a paddock, which had been sown to, wheat and canola for the last 3 years. Pre-drilled urea also increased grain protein. The best outcome in this demonstration was achieved with 50 kg/ha of pre-drilled urea, 72 kg/ha of seed and a basal application of 18:20:0.
- Higher seeding rates showed no benefits in yield and resulted in substantially higher levels of screenings and protein in this dry season.

Acknowledgments

Thank you to Michael Agars for setting up and managing the trial.

PIRSA RURAL SOLUTIONS

Section

2

Section editor: ***Amanda Cook***

SARDI, Minnipa Agricultural Centre

Pulse/Oilseeds Researcher

Break Crops

Break crops are used within the farming system to reduce cereal disease levels and allow grass weed control. These crops can be very profitable opportunity crops, especially if an early season break occurs.

Despite the late start and relative dry conditions in 2002 some of the break crops, especially the peas, performed well this year indicating a high level of drought tolerance.

While current high grain prices makes break crops a viable option, the increase in the wool and sheep prices may influence farmers decisions to grow breakcrops in 2003 on Eyre Peninsula.

Trials to select new breeding lines which are better adapted to our environment were conducted at Minnipa in 2002 for peas, beans, rough seeded lupins, canola (conventional, triazine and Clearfield varieties) and mustards. The breeding programs aim to release new varieties in the future which preform well in our lower rainfall environment.

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United Grower Holdings

Location
Minnipa Agricultural Centre
Paddock - South 5

Rainfall
Av. annual : 326 mm
Av. G.S.R.: 241 mm
2002 total : 278 mm
2002 G.S.R.: 219mm

Paddock History
2002: Pulse trials
2001: Excalibur Wheat
2000: Bt Schomburgk Wheat
1999: Grass Free Pasture

Soil Type
Sandy loam, pH 8.9

Pulse overview and performance on Upper Eyre Peninsula in 2002

Larn McMurray[1] and Amanda Cook[2]

[1]SARDI, Waite Precinct; [2]SARDI, Minnipa Agricultural Centre.

Summary and performance

Despite the difficult dry season in 2002, pulse performance on the Upper Eyre Peninsula was encouraging. The capacity of peas to better tolerate low rainfall, dry conditions than all other pulses was particularly evident at Minnipa last year (Table 1). All pulse trials at Minnipa were sown later than ideal due to the late break to the season, however early season conditions were favourable for good establishment and growth. After significant falls of rain in early August, conditions then turned dry and yield potential was further reduced by strong hot wind events at frequent intervals during September, with September 15 being particularly harsh. Early flowering pea lines suffered high levels of flower abortion and subsequent yield reductions due to this event. Conditions remained dry through to a late rainfall event in early October which allowed late maturing peas to fill well. Yields in beans and chickpeas were also significantly improved by this late event although yield potential had already been greatly reduced by the dry conditions. This late rainfall event was likely to be responsible for pod splitting in immature pea pods. Pulses matured quickly and were particularly prone to shattering which is often a problem in low rainfall areas or when pulses have suffered from moisture stress during pod filling. Early harvesting is vital under these conditions not just to reduce shattering, but also to aid in harvesting. Pulses left in the paddock once they have matured will lodge further making harvesting extremely difficult and often impossible.

Table 1: Pulse crop performance at Minnipa Agricultural Centre in 2002.

	Beans	Chickpeas	Peas	Vetch
Trial mean yield (t/ha)	0.87	0.72	1.37	0.28
Control variety mean	0.90	0.79	1.40	0.34
***Gross margin (2002 price)**	$160	$231	$414	-$1**
***Gross margin (5 yr. avg.price)**	$86	$137	$167	-$39**
CV%	9.2	8.3	5.9	23.4
Date sown	31 May	4 June	26 May	4 June
Yield limiting factors	Late sown, Pre & Post Flowering moisture stress	Late sown, Pre and Post flowering moisture stress	Post flower moisture stress, late sown, high temperatures during flowering, pod splitting	Pre & Post flowering moisture stress, short height at harvest

Note control varieties are: Beans- Fiesta, Chickpeas-Howzat, Peas-Parafield, Vetch-Blanchefleur.

**Gross margins are a guide only and do not include freight, insurance and machinery operation costs and assumes each grain achieved maximum grade (if appropriate).*

***Vetch generally not grown as grain crop, used as green manure/forage/hay.*

Peas

Parafield's relative performance at Minnipa in 2002 was below its long term average due to yield loss through pod splitting and the late rainfall event in early October being of more benefit to late maturing varieties like Mukta, Soupa and Alma. Despite these factors Parafield was still slightly higher yielding than Alma and continues to be a very good option for the Upper Eyre Peninsula. At Lock a frost event in September combined with pod splitting were the major factors affecting yield performance. Again later flowering and maturing lines were generally better off with some early and mid flowering lines being particularly harshly hit by the frost. There is currently no pea variety with flowering/pod filling tolerance to frost and avoidance is the only mechanism for reducing yield loss. If you are particularly prone to frosts at a certain time of the year you can aim to select a variety that will flower outside this window, but be aware that if you delay flowering you can run into flower abortion problems when daily maximum temperatures rise above 25°C.

Pod splitting in peas in 2002

Pod splitting appeared to occur due to the immature grain taking up moisture and swelling inside the pod, causing the pod to split open. Limited trial results indicated that Parafield was more susceptible than other varieties whereas Kaspa was not affected. This condition was identified in a number of commercial pea crops on the Upper Eyre Peninsula last season and was similar to observations in the Victorian Mallee after late rainfall events in the 2000 season.

New variety for 2003-04

The new dun type pea Kaspa, which has been evaluated at Minnipa for 4 years and Lock for 3 years, continued to perform well in 2002. Yields of Kaspa were down on previous performance but still comparable with Parafield. Long term yield data on the UEP suggest this variety is higher yielding than Parafield in this area. Growers are advised to consider this variety carefully in areas prone to early periods of high temperature stress due to its late and condensed flowering period (about 5 days later than Parafield). Kaspa is resistant to downy mildew, has improved lodging resistance and weed competitiveness over Parafield and is also resistant to shattering. Limited seed is expected to be available for sowing in 2003 and more widely available in 2004.

Table 2: Selected Stage 4 Pea line yield results from Minnipa and Lock in 2002 and long term predicted (1996-2002) (Yield as a % of Parafield).

Variety	Minnipa		Lock	
	2002	1996-2002	2002	1996-2002
Alma	97	85	115	86
Dundale	102	89	123	89
Dunwa	100	89	108	89
Kaspa	100	106	103	106
Parafield	100	100	100	100
Mukta	107	94	113	92
Santi	95	91	100	92
Sturt (90-131-*27-7)	99	102	138	102
PX-96-57-8	114	NA	77	NA
Parafield Yield (t/ha)	1.40	1.62	1.08	2.17

Agronomic results

Results from low rainfall seeding rate trials in South Australia last year suggest Kaspa is more responsive to higher plant densities than Parafield. Target plant densities of 50-55 plants/m^2 are recommended to maximise yields of Kaspa, compared with 40-45 plants/m^2 with Parafield.

Future varieties

Effort into breeding peas for low rainfall environments continued in 2002 with 3 breeding trials being conducted at Minnipa. The season was particularly beneficial for selecting lines with adaptation to drought tolerance. One of the more advanced breeders lines to do well in 2002 was the SARDI line PX-96-57-8, derived from a cross involving Parafield and a European line. This line was the highest yielding entry at Minnipa but low yielding at Lock due to frost. Further evaluation is required.

Beans

Beans were sown much later than ideal in 2002 due to the late break. However yields were respectable given the late start and the dry finish. Last year's result supports data from previous years which suggest that beans can be a profitable opportunity crop on the Upper EP, particularly if an early season break occurs. Vegetative growth was relatively good but still less than ideal and pod height above ground was low. Late rains in early October were critical in allowing late pods to fill and set yield. Fiesta was the leading variety across both sites on the Upper EP in 2002. A promising outcome of the trials was the performance of several new breeders lines. All three breeders lines listed in the table below have increased disease resistance attributes over Fiesta, with the two Icarus*Ascot crosses having multiple resistance to rust, botrytis and ascochyta.

Table 3: Selected Stage 4 Bean line yield results from Minnipa and Lock in 2002 and long term predicted (1996-2002) (Yield as a % of Fiesta).

Variety/Line	Minnipa		Lock	
	2002	1996-2002	2002	1996-2002
Ascot	68	71	104	80
Barkool	97	84	94	84
Fiesta	100	100	100	100
Fiord	92	87	96	90
Icarus*Ascot/56/1/B	105	96	101	94
Icarus*Ascot/7/3	117	112	80	100
483/3-S	100	104	101	102
Fiesta yield (t/ha)	0.90	1.10	1.03	1.78

Breeding on the UEP

Minnipa continued to be a major breeding site for beans in low rainfall areas with an early generation trial conducted in 2002. The major traits required at sites such as Minnipa include early flowering to enable pod set before the onset of moisture and heat stress, the lowest pods to be at a reasonable height for harvesting, seed that does not stain in response to environmental stress and a good level of disease resistance. Disease resistance is of particular importance because although the risk of serious disease in lower rainfall areas is low the cost of control is high. Developing disease resistant varieties would enable crops to be grown without the need to apply fungicides in all but the wettest years.

The three breeders shown in Table 3 are currently undergoing multiplication for release over the next 2-3 years, with 483/3-S being the closest to release at this stage.

Chickpeas

Table 4: Selected Stage 4 Chickpea line yield results from Minnipa and Lock in 2002 and predicted long term (1996-2002) (Yield as a % of Howzat).

Variety/Line	Minnipa		Lock	
	2002	1996-2002	2002	1996-2002
Howzat	100	100	100	100
Tyson	95	89	93	92
Flip94-508C	68	80	55	86
Flip94-509C	96	100	104	100
ICCV96836	91	94	109	96
Sona-4028	86	71	61	79
Howzat yield (t/ha)	0.79	0.69	0.57	0.98

Yields of the highest yielding chickpea lines were similar to those of the best bean lines, although yield variation was greater in the chickpeas. Chickpeas generally produce lower amounts of vegetative growth through winter than peas and beans on the Upper Eyre Peninsula and although they were relatively well grown by the end of August last year they were still very much behind these other crops. Like the Stage 4 bean trial the chickpeas were sown later than ideal and this combined with the long dry period led to overall low vegetative growth. Late rain enabled pods to fill although the general dry spring conditions had already greatly reduced the yield potential of the trial. The highest yielding line at Minnipa and Lock was Howzat which is moderately susceptible to ascochyta. The growing of Howzat still requires regular fungicides through the year. It is less likely to be economic in lower rainfall areas, even though the risk of ascochyta is less in these areas.

Before chickpeas become a realistic opportunity crop in low rainfall areas the level of ascochyta resistance needs to be improved. Unfortunately some of the first releases with improved ascochyta resistance are not particularly well suited to low rainfall areas, as evidenced by the results of Flip94-508C and ICCV96836 in Table 4. Promising desi lines more likely to be suited to lower rainfall areas include several selections from Heera and Sona, and 3 lines from WA which were assessed for the first time at Minnipa last year with some out-yielding Howzat. All are early maturity, but MS to MR for ascochyta though. Continued breeding for adaptation to low rainfall areas is required.

Vetch

As in previous years with late starts and dry finishes, vetch vegetative growth and grain yield production were very poor on the Upper Eyre Peninsula last year. Like a number of other pulse crops vetch is very slow growing through winter and if it is moisture stressed during spring vegetative growth will be severely retarded. The SARDI vetch breeding program has produced a number of very promising crosses for the low rainfall areas which are currently under evaluation in SA, WA and Victoria. The lines showing promise are 98/C*Mor(5) purple, 98/LNG*Mor(1), SA-33224, 98/LNG*Mor(3) and 98/Mor*BF(2). These lines have earlier maturity than Morava and are more resistant to rust and ascochyta than Languedoc and Blanchefleur. Evaluation of these lines will continue in the future.

Conclusions

- Pulses continued to show they can be successfully grown in low rainfall areas if the correct agronomic packages are implemented.
- Peas continue to be the most robust and highest yielding pulse crop in low rainfall areas especially with delayed opening breaks, although frost severely reduced yields at Lock.
- Early harvesting of pulses in low rainfall environments is essential for maximum yield, quality and ease of harvest.
- Parafield and Kaspa are both options for pea growers in low rainfall areas, although Kaspa is later flowering and may not be suited to all areas.
- Kaspa requires a 20% higher seeding rate than Parafield for maximum yields.
- Pod splitting in immature pods in Parafield reduced yields, but was not identified in Kaspa.
- Disease resistant bean and chickpea material with greater adaptation for low rainfall areas is currently being evaluated and when available will greatly increase the ability to grow these crops in seasons with early breaks.
- Vetch performed poorly under last year's conditions due to the late break delaying sowing and leading to very low levels of vegetative growth.

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Canola and mustard overview and performance in dry environments

***Trent Potter*[1] *and Amanda Cook*[2]**

[1]*Senior Research Officer, SARDI, Struan;* [2]*Research Officer, SARDI, Minnipa*

Location
Minnipa Agricultural Centre
Paddock North 2

Rainfall
Av. annual: 326 mm
Av. G.S.R.: 241 mm
2002 total: 278 mm
2002 G.S.R.: 219mm

Paddock History
2002: Canola trials
2001: Frame Wheat
2000: Grass Free Pasture
1999: Grass Free Pasture

Soil Type
Sandy loam, pH 8.9

Low rainfall canola varieties

There are several types of canola currently available for low rainfall areas. These include conventional varieties, triazine tolerant varieties and Clearfield canola. The advantages and disadvantages of each type will be discussed.

Trials conducted at Minnipa and other low rainfall sites in 2001 and 2002 tested a range of early maturing canola varieties. When looking at these results (Table 1) be aware that oil contents in 2001 were high compared to poorer years and oil contents for 2002 are not yet available. In future it we may need to achieve over 42% oil to avoid a dockage in price.

Early maturing conventional varieties have been improved over the last few years, with Ag-Outback having a higher grain yield than Monty, but a slightly lower oil content. Rivette, released in 2001 from NSW Agriculture, showed improved yield and oil content. Both Ag-Outback and Rivette are later flowering than Monty.

The highest yielding early maturing Clearfield variety in trials last year was 44C73 which produced similar yields to the best conventional varieties. Oil content was relatively low compared to the highest varieties. Surpass 402CL lodged early in all trials in 2001 and produced poor grain yields.

Table 1: Grain yield (relative to Ag-Outback) and oil content of conventional and Clearfield canola varieties at Minnipa, 2001 and 2002.

Variety Conventional	Grain yield 2001 (relative to Ag-Outback)	Oil content 2001 (%)	Grain yield 2002 (relative to Ag-Outback)
Monty	94	39.1	-
Ag-Outback	100	38.8	100
Rivette	103	42.1	91
Clearfield			
44C73	102	39.7	80
Surpass 402CL	79	43.1	70

When triazine tolerance has been crossed into canola it has been shown that there is less radiation use efficiency is less than in the conventional parent, resulting in less biomass at maturity. Grain yields have been shown to be up to 25% lower than conventional varieties and oil content is reduced by 2-5% (a greater reduction in low oil environments). The other result of incorporating the TT trait into a variety is that flowering date is delayed by several days. This is probably the major reason why it has been so difficult to select early maturing TT varieties.

In trials in 2001, Karoo produced higher yields than the other early TT varieties but a reduced oil content (Table 2). ATR-Eyre, a new variety from Ag-Vic, had a high oil content but lower yield. Surpass 501TT is an early-mid flowering variety with high oil content. Yields in 2002 were much lower than in 2001 but varieties responded similarly.

Where do these varieties fit?

If you are certain that your paddock is virtually free of broadleaved weeds then the best option is to use conventional varieties. These have higher yield and oil content.

Table 2: Grain yield (t/ha) and oil content of triazine tolerant canola varieties at Minnipa, 2001 and 2002.

Variety Triazine tolerant	Grain yield 2001	Oil content 2001 (%)	Grain yield 2002
Karoo	1.32	38.3	0.61
ATR-Eyre	1.17	40.5	0.33
Surpass501TT	1.22	41.8	0.58
ATR-Beacon	1.37	39.3	0.59

However, the Clearfield system may be more applicable if you have a Brassica weed problem. The best Clearfield varieties nearly match the conventional varieties for yield and oil but are more expensive (seed plus herbicide package is about $80 per hectare). Also the herbicide (On-Duty) is a group B herbicide that may cause problems if you have resistant ryegrass.

Triazine tolerant canola has been shown in trials to have lower yield than the other canola varieties and many varieties have lower oil contents as well. However the cost of the TT package is relatively inexpensive. On low rainfall alkaline soils only a low rate of simazine (perhaps 1.5 L/ha) will be able to be used due to carry over problems but this rate has been shown to be very effective at controlling Brassica weeds.

The last two years have shown that sowing date and conditions during the growing season have a major effect on canola and mustard yields. Crops in both 2001 and 2002 were sown in late May or early June. With the exceptional season in 2001, high grain yields were achieved. However 2002 was tougher and much lower grain yields were produced. In order to produce high yields it is necessary that canola be sown as early as possible, given good weed control, and sowing as late as was the case in the last two years is not recommended. The end of the third week of May could be used as a cut-off point for including canola in the rotation because later sowings, rely heavily on a very favourable spring to ensure good yields.

The future

Mustard *(Brassica juncea)*

Breeding programs for canola quality *B. juncea* (Indian mustard) commenced in Australia in the late 1970's and early 1980's. The programs aimed at producing canola quality *B. juncea* for lower rainfall environments. *B. juncea* has a number of potential advantages over *B. napus*, including enhanced seedling vigour, blackleg resistance and shatter resistance, plus higher tolerance to drought and high temperature stresses. In order for canola quality *B. juncea* to be used interchangeably with *B. napus* in the market place, it has been important to increase oleic acid levels to match the *B. napus* level of 60%. Early maturing, high yielding Australian canola quality *B. juncea* lines are currently being crossed with higher oleic acid sources from Canada. Canola quality cultivars are expected to be available for commercial production in the next few years. Initially it is likely these will be conventional varieties, but additional herbicide resistant types will also be released, as in canola.

Table 3: Grain yield (t/ha) and oil content of mustard lines and canola varieties at Minnipa, 2001 and 2002.

Variety	Grain yield 2001	Grain yield 2002
Canola		
Ag-Outback	1.47	0.47
Rainbow	1.49	0.29
Mustard		
Non-canola quality	1.34	0.50
Canola quality	1.15	0.46
Arid (Canadian)		0.35

As shown in Table 3, in years where canola yields above about 1 t/ha, the mustard lines under test produce lower yields than commercial canola varieties. However, in lower yielding years such as 2002, the mustard lines perform better than canola. At present, it seems that mustards that are more likely to produce canola quality grain are lower yielding than mustards that have lower levels of oleic acid (the fatty acid that makes canola oil monounsaturated and therefore more healthy to eat). However much of this yield difference is caused by the later flowering from crossing Australian adapted mustards to later flowering but better quality Canadian lines. An example of this is the variety Arid that was released in Canada in 2002. This is late flowering and low yielding under our conditions. It is hoped higher yields will be achieved once earlier maturity high quality mustard lines are developed.

Canola

We are attempting to select canola lines that are better adapted to low rainfall conditions in SA. Single plants have been selected from our trials at Lameroo in the southern Mallee since 1998 and those lines with the highest oil content are yield tested at Lameroo and Minnipa. The aim is to test elite lines from these sites in trials throughout Australia and to release varieties of conventional and TT canola with high yield and increased oil content. In 2002, due to the drought in the Mallee, all single plant selections taken were from Minnipa. As Table 4 shows, increased yields have been achieved in both triazine tolerant and conventional canola lines. We hope to release an early flowering triazine tolerant variety in the next two years that will give more consistent yields and higher oil content than current commercial varieties. While there may also be a place for an early flowering conventional variety, it is more likely that these lines will be crossed to develop even better triazine tolerant varieties in future.

Table 4: Grain yield (t/ha) of canola selections at Minnipa in 2002.

Variety	Conventional	Triazine tolerant
Best control	0.63 (Ag-Outback)	0.66 (ATR-Beacon)
Highest yielding line	0.78 (BLN2062*SL021)	0.75 (TO080*SP003)

Acknowledgements

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Grass-free Legume Breaks - How Long Do They Influence Crop Yield?

Neil Cordon[1] and Ian Creeper[2]

[1]SARDI, Minnipa Agricultural Centre; [2]Formerly SARDI, Minnipa Agricultural Centre

Location
Kyancutta
Peter, Darren and Brett O'Brien
Central Eyre Agricultural Bureau

Rainfall
Av. Annual total: 294 mm
Av. Growing season: 226 mm
2002 total: 218 mm
2002 Growing season: 179 mm

Yield Potential
Barley 1.78 t/ha

Paddock History
2002: Barley
2001: Wheat
1999: Peas, Lupins, Medic, Grass
1998: Barley

Soil Type
Dune-swale sandy loam

Plot Size
30 m x 1.6 m x 3 reps.

Key Messages

- **Poor performance of wheat after clean medic was not observed in 2001.**
- **The positive influence of grass-free legume phases may be short-lived on some root diseases.**
- **Potential yields can be achieved with low levels of root disease present provided other agronomic practices are correct.**

Why do the trial?

The use of break crops has led to many changes within the farming system including intensified cropping, reduced tillage and increases in cereal yields, especially in medium/high rainfall environments. Break crops reduce cereal diseases, allowing cereals to be cropped more frequently. Within low rainfall environments the risk associated with growing certain break crops is much higher. Some farmers were concerned with the poor performance of wheat after a clean medic pasture. This trial was established to determine the cereal yield benefits after different break options under Kyancutta conditions, and to determine the reason for any yield increases.

This was the third and final year of the trial, with previous results in the EPFS 2001 Summary (pg 44).

How was it done?

2000 - First Year

Grassy pasture (brome grass, rye grass, wheat and oats), medic, peas and lupins were sown separately in 3 broad scale replicated strips. Targa® was applied at early tillering to all plots except the grass plots. The grassy plots were spray topped. An initial soil sample was collected in April 2000 to determine starting soil disease levels followed by a second soil sample in October 2000 to determine what effect each break option had on disease levels (Table 1).

2001 - Second Year

Excalibur wheat was sown on the plots of grassy pasture, medic, peas and lupins. Yield results are shown in Table 1.

2002 - Third Year

After predrilling urea @ 30 kg/ha, Barque barley was sown @ 70 kg/ha into the 2001 wheat stubble plots on June 5, with 18:20:0 Zn 1% fertilizer @ 70 kg/ha. Sowing was with Harrington points which cultivated to a depth of 5 cm.

Weed management consisted of Sprayseed® @ 0.9 L/ha in late May followed by a mixture of trifluralin @ 1.4 L/ha and glyphosate @ 1.0 L/ha just prior to seeding. Zinc sulphate was foliar applied @ 2.0 kg/ha at mid tillering. A third soil test was taken in February to monitor trends in disease levels prior to sowing the barley.

What happened?

The barley grew exceptionally well with yields exceeding the potential for the site. There were no yield differences between the treatments established in 2000, with little difference in the root disease levels between plots except for an increase in Take-all in the medic treatment.

Comparison of the first and third samplings indicates the following disease trends: CCN has decreased, Rhizoctonia is unchanged, and Pratylenchus neglectus (Pn), Pratylenchus thornei (Pt) and take-all have all increased.

Table 1: Grain yields (wheat in 2001 and barley in 2002) and root disease levels at Kyancutta.

Break crop options	CCN DNA/g soil	Rhizoctonia DNA/g soil	P.neglectus DNA/g soil	P.thornei DNA/g soil	Take-all DNA/g soil	Protein %	Yield t/ha
Initial Test	2 (L)	65 (M)	5 (M)	Nil	Nil		
2001 Wheat							
Grassy Pasture	Nil	66.6 (M)	5.9 (M)	0.42 (L)	12.2 (L)	10.6	2.73
Medic	0.67 (L)	61.4 (M)	2.5 (L)	Nil	Nil	10.8	3.47
Lupins	Nil	44.5 (M)	Nil	Nil	10.4 (L)	10.5	3.41
Peas	Nil	60.1 (M)	Nil	Nil	13.7 (L)	10.6	3.61
LSD (P<0.05)							0.30
2002 Barley							
Grassy Pasture	Nil	84 (M-H)	3.7 (L)	Nil	15 (L)	12.5	1.90
Medic	Nil	71 (M-H)	5.0 (M)	Nil	97 (M)	12.9	2.00
Lupins	0.3 (L)	74 (M-H)	8.3 (M)	0.33 (L)	17(L)	11.7	2.10
Peas	Nil	61 (M)	9.3 (M)	1.67 (L)	17 (L)	10.9	2.04
LSD (P<0.05)							NS

Disease levels are indicated in brackets (where L = low, M = medium, H = high).

Break Crops

What does this mean?

- The 2002 results suggest that there was no influence of the previous grass-free breaks on yield in the second crop phase.
- Under low to moderate disease levels potential yields can be achieved provided all the other agronomics are in place.
- The root disease cleaning effect of a break crop has had a positive influence on CCN, no influence on reducing rhizoctonia and only a short term (one year) effect on reducing Pn. As expected, the level of take-all increased dramatically after the susceptible wheat crop and the favourable spring conditions for inoculum build up in 2001.
- It appears that the significant improvement of wheat yields in 2001 following grass-free break crops was due to a combination of Pn reduction and possible supply of farming system nitrogen. Where barley was sown (2002) on wheat stubble the influence of the break crops did not dominate the yields due to the wheat phase building up Pn, Pt and take-all levels.

Acknowledgements

Peter, Darren and Brett O'Brien, Kyancutta, for the work they carried out during the duration of the trial.

GRDC Grains Research & Development Corporation

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Best practice	Try this yourself now	Almost ready	Searching for answers	Searching for problems

Key to symbols

Summer Crops at Minnipa: How did they go, what did they do to the following wheat ?

Nigel Wilhelm,

SARDI, Minnipa Agricultural Centre

Location
Minnipa
Scott, Jane, Locky and Pat Forrest

Rainfall
Av. Annual total (mm): 326
Av. Growing season (mm):
111 (Oct -Mar)
241 (Apr-Oct)

Actual annual total (mm):
354 (2001), 278 (2002)
Actual growing season (mm):
88 (Oct '01-Mar '02)
219 (Apr-Oct '02)

Yield
Potential:
Sorghum - 1.8 t/ha
Sunflowers - 0.9 t/ha
Wheat - 2.2 t/ha
Actual:
Sorghum - 1.0 t/ha
Sunflowers - 1.1 t/ha
Wheat - 2.0 t/ha

Paddock History
2001: Grass free medic pasture
2000: Wheat
1999: Spray topped pasture

Soil
Land System: Undulating plains with deep and shallow red calcareous soils
Major soil type description: Deep calcareous sand

Diseases
Helicoverpa (Heliothis) reduced establishment of summer crops, especially sunflowers.
Rutherglen bug during grain fill of sunflowers.

Plot size
4-9 m x 100 m.

Other factors
Zinc deficiency in summer crops on top of the sand hill, especially in corn and sorghum.

Key Messages

- **Summer crops show some promise as a new rotation option for deep sandy soils of Upper EP.**
- **Wheat performed as well after a summer crop as it did after a grass free medic.**
- **Forage sorghum may be a good option for graziers with deep sandy soils looking to reduce a late summer/autumn feed gap or to finish off stock for market.**

Why do the trial?

A range of summer crops were grown on a sand dune near Minnipa to test their ability to survive and perform under conditions typical of the Upper EP.

Many farming enterprises in the cropping belt of South Australia are under severe strain due to financial (low commodity prices, increasing costs), productivity (herbicide-resistant weeds, disease burdens) and sustainability (salinity, poor water-use efficiency) pressures. Continued fine-tuning of these systems is not providing sufficient improvements quickly enough (or at all) to respond to these pressures adequately. But integration of summer crops such as sorghum, sunflower or corn into these farming systems has the potential to provide rapid and substantial relief to all three of these pressures. SARDI has been conducting a trial programme for the last three years which is investigating the potential of summer crops to grow under conditions typical of the cropping districts of South Australia.

How was it done?

A grass-free medic pasture on a deep calcareous sand hill was knocked-down in early September 2001 and the first summer crop plots (sunflowers and corn) were seeded on 25 and 26 September 2001. The rest of the trial was seeded on 5-6 October 2001 when soil temperature at 9.00am reached 16°C. This is the earliest that sorghum and cotton can be seeded. Plots were 100 m long, 4-9 m wide and ran from a swale area up and over a low sand hill. There were no major soil constraints to 1 m of depth, except for low fertility. Summer crops were seeded with a double disc precision planter using fluid fertilisers side-banded to deliver N, P and Zn. Plots received 17-30 kg N/ha, 9-15 kg P/ha and 0.3-1.0 kg Zn/ha; the range having been caused by difficulties with the fluid pump. A second knockdown and spray for red legged earth mite was applied at seeding; trifluralin @ 2 L/ha was applied post seeding on broad-leaved summer crops and atrazine @ 3 L/ha was used on corn and sorghum.

Flights of Helicoverpa (Heliothis) as crops emerged damaged all crops but were most severe on sunflowers, cotton and sunn hemp. They were sprayed to prevent further damage.

Corn and grain sorghum received a further application of atrazine mid season @ 2 L/ha and late season weed control for all grain crops was achieved with a weed-wipe of glyphosate, Garlon® and wetter late in the season. Sunflower and sorghum were sprayed for Rutherglen bug during grain fill.

Grain yields were measured separately at the base and on the top of the sand hill in late February.

The trial site was heavily prickle-chained before the break in 2002 (to smash up sunflower stalks) and the whole paddock was seeded with Krichauff wheat on 28 May with 55 kg/ha of 17:19 Zn 2.5% A header strip was taken out of a selection of previous summer crop plots near the top of the sand dune at maturity.

What happened?

Summer crops were direct seeded into good moisture and all crops emerged well. However, Helicoverpa thought the emerging plants looked very tasty (as other crops and pastures dried off) and caused severe damage to all crops, especially sunflowers, cotton and sunn hemp (a tropical legume) before they were sprayed. Cotton and sunn hemp never recovered. The number of plants which established (Table 1) shows the excellent job that the double disk precision planter can do (establishments of 80-90% with corn and sorghum) and the damage that Helicoverpa did to sunflowers and cotton.

Figure 1: Local garden gnome frolicking in sunflowers at Minnipa, 2001-02

The cool start to the summer of 2001/02 compensated for the lack of rain resulting in sunflowers and corn which grew well (Figure 1). Sorghum was slow to start however because it prefers warmer temperatures. However the sorghums picked up after Christmas and put on a lot of growth in the new year. Millet struggled all the way through and did not produce any grain worth harvesting (it is the most shallow rooted of the summer crops tried at this site).

Variety had a big impact on the final performance of summer crops (Table 1). For example, grain sorghum yields varied from 0.4 to 0.94 t/ha depending on the variety sown. Row spacings were also important to yield. Skip rows have a reputation for performing well under very dry conditions in northern Australia where they are regarded as a way to "drought proof" a crop. We have not seen the same advantage with them in southern Australia yet but in corn and sorghum they did match the yield of solid row plantings. We have seen skip rows outperform solids at other sites and they do have some other management advantages (eg. faster seeding, easier inter row weed control) so this technique still has some merit.

Yields of summer crops were encouraging given that they flowered and filled grain without any effective rainfall (rainfall records show that normally about an inch of rain would fall over this period) and produced this grain on a deep sand (Table 1). Deep sands are often poor performing areas of the paddock for winter crops.

Table 1: Establishment and yield of summer crops at Minnipa in 2001/02 and the subsequent wheat crop.

Crop	Variety	Row Spacing (m)	Establishment		Yield (t/ha)		
			plants/ha	% of seeds planted	Flat	Sand dune	Wheat in 2002[3]
Cotton (Siokra V16)	V16	Solid 1[1]	10,800	15	0[4]	0	2.02
Sunn Hemp		Solid 0.5	15,000	9	0	0	
Sunflower; half nutrients	Advantage	Skip 1[1]	19,167	68	-[5]	0.71	
Sunflower	Advantage	Skip 1	15,000	53	-	0.70	
Sunflower; late sowing	Advantage	Double skip[2]	10,000	34	-	0.77	
Sunflower	Advantage	Solid 1	11,667	39	-	1.11	1.76
Sunflower; late sowing	Advantage	Skip 1	8,333	29	-	0.74	1.79
Sunflower	Hysun 25	Skip 1	15,833	56	-	0.57	1.99
Corn; late sowing	3751	Skip 1	31,667	100	0.47	0.62	1.17
Corn	53IT	Skip 1	30,000	94	0.29	0.15	
Corn	3751	Skip 1	29,167	92	0.72	0.60	1.21
Corn; late sowing	3751	Double skip	26,250	88	0.5	0.25	0.99
Corn	3751	Solid 1	27,500	93	0.49	0.61	1.09
Forage sorghum	Bettagraze	Solid 0.5	86,667	73	3.7[6]	4.2[6]	1.23
Forage sorghum	SuperDan	Solid 0.5	73,333	27	2.3[6]	2.3[6]	1.22
Forage sorghum	Cow Pow	Solid 0.5	93,333	38	3.4[6]	1.6[6]	
Millet	Shirohie	Solid 0.5	320,000	15	0	0	1.90
Grain sorghum	Western Red	Solid 1	50,833	114	0.52	0.55	1.06
Grain sorghum	Western Red	Skip 1	37,500	89	0.58	0.40	
Grain sorghum	86G87	Skip 1	30,000	71	0.63	0.53	
Grain sorghum	Legend	Skip 1	30,833	73	0.61	0.90	1.16
Grain sorghum	Goldrush	Skip 1	36,667	87	0.5	0.94	1.36
Grain sorghum	DK35	Skip 1	29,167	46	0.71	0.78	
Chemical Fallow							1.70
Grass-free Medic							1.81

1 Solid 1 means all rows were seeded at 1 m row spacings, skip means that every 3rd row was not seeded.
2 Double skip means that rows were seeded at 1 m row spacings but every 3rd and 4th row was not seeded.
3 The trial site was seeded with Krichauff wheat in 2002.
4 Helicoverpa (Heliothis) flights soon after seeding decimated all plants as they emerged and the crop failed to establish.
5 Helicoverpa (Heliothis) flights soon after seeding decimated plants in this area of the trial and the crop failed to establish.
6 Values are DM production in early February for flat and total DM production for 2 cuts on sand dunel (early Feb plus late March).

The best variety of forage sorghum, Bettagraze (which has been clearly the best performer in all our trials so far) produced at least 4.2 t/ha of dry matter by the end of summer. This production netted nearly $250/ha (Table 2) assuming that all the production was converted into hay and sold at $100/t. Recent experiences with forage sorghum hay at Balco (the hay exporters based at Balaklava) suggest that forage sorghum hay will be suitable for the Japanese dairy market.

All the grain summer crops failed to produce positive gross margins (and most lost heaps !) but this was more to do with the costs of inputs rather than their inability to survive under Upper EP conditions (Table 2). For example, the best sunflowers and grain sorghum produced about 1 t/ha of grain in a summer of below average rainfall, about the same as wheat under comparable conditions in winter. I am confident that with more experience, we will be able to achieve the same or better yields with input costs much lower. Pest control will probably always be high relative to winter crops but we can do weed control much smarter (up to $86/ha was spent on herbicides; a less generous approach to application rates and better timing would have seen this cost reduce substantially with better weed control achieved) and fertiliser management also suffered from the policy of not skimping. For example, when we started seeding the trial we used more than $80/ha of Zn chelate in the fertiliser brew. By the end of the trial we had cut this back to $20/ha and yet Zn deficiency was no worse in the last seeded plots. P was supplied from APP, an expensive source of fluid P. N was supplied from UAN, a more expensive source than urea. Seed costs for summer crops are also likely to remain high relative to winter crops because most are hybrids which means that new seed must be purchased every year and some are very expensive (for example, we spent up to $75/ha on corn seed).

Another factor which could improve the financial returns from summer crops calculated here are the values of the grain. For example, I have used longer term values for corn and sorghum (which are feed grains) rather than the current high prices, I have not allowed for the high demand for corn in the dairy industry (not very relevant to upper EP but WA dairy farmers are paying up to $350/t for corn on farm) and we could have grown sunflower varieties which have yielded as well as Advantage at other sites which are suitable for the birdseed market and have sold in Adelaide for $700/t !

Table 2: Gross margins for summer crops at Minnipa in 2001/02.

Crop	Variety	Row Spacing (m)	Income		Variable costs of production ($/ha)	Gross Margin ($/ha)
			Yield[1] (t/ha)	Value ($/t)		
Cotton (Siokra V16)	V16	Solid 1	0		441	-441
Sunn Hemp		Solid 0.5	0		310	-310
Sunflower; 1/2 nutrients	Advantage	Skip 1	0.71	250	230	-52
Sunflower	Advantage	Skip 1	0.7	250	460	-285
Sunflower; late sowing	Advantage	Double skip	0.77	250	230	-37
Sunflower	Advantage	Solid 1	1.11	250	460	-182
Sunflower; late sowing	Advantage	Skip 1	0.74	250	232	-47
Sunflower	Hysun 25	Skip 1	0.57	250	277	-134
Corn; late sowing	3751	Skip 1	0.62	250	297	-142
Corn	53IT	Skip 1	0.29	250	321	-283
Corn	3751	Skip 1	0.72	250	297	-147
Corn; late sowing	3751	Double skip	0.5	250	254	-191
Corn	3751	Solid 1	0.61	250	483	-330
Forage sorghum	Bettagraze	Solid 0.5	4.2	100	263	247
Forage sorghum	SuperDan	Solid 0.5	2.3	100	268	107
Forage sorghum	Cow Pow	Solid 0.5	3.4	100	273	152
Millet	Shirohie	Solid 0.5	0		240	-240
Grain sorghum	Western Red	Solid 1	0.55	150	295	-217
Grain sorghum	Western Red	Skip 1	0.58	150	281	-194
Grain sorghum	86G87	Skip 1	0.63	150	281	-186
Grain sorghum	Legend	Skip 1	0.90	150	282	-191
Grain sorghum	Goldrush	Skip 1	0.94	150	282	-207
Grain sorghum	DK35	Skip 1	0.78	150	282	-175

1 *The best yield from the flat or sand hill was used for income calculations.*

The yield of wheat following summer crops was also encouraging. In the absence of any major disease or weed problems, Krichauff yielded as well after sunflowers as it did after a grass free medic (Table 1), despite a dry autumn and tough finish. Wheat yields after corn and sorghum were affected by atrazine residues, and this must always be allowed for if planning a rotation with either of these two summer crops. Yield of wheat after millet was slightly better than after medic which is consistent with reports from WA that wheat crops have performed very well after millet.

What does this mean?

- Summer grain crops performed well on a deep calcareous sand, despite below average rainfall.
- Forage sorghum produced feed levels which would fill an autumn feed gap.
- Input costs for summer grain crops must be reduced substantially from the levels used in this trial before they will be financially viable.
- Summer crops prior to wheat did not depress wheat yields providing there were no herbicide residues. In the case of millet, wheat production was better than after a grass-free medic.

Trials will be continuing across the cropping districts of SA to estimate the potential of summer crops to perform under local conditions and to develop agronomy packages which will optimise production for least cost. A large gap in our knowledge about summer crops in southern Australia is how well they will act as break crops in our rotations for the diseases important in our cropping systems. For example, the sorghums have a reputation as a very good break for Pratylenchus but I have yet to see them used in a rotation where Pratylenchus is a major problem.

Acknowledgments

Brenton Growden and Terry Blacker (SARDI, Pt Lincoln) for running the trial.

Shane Doudle and Wade Shepperd (SARDI, MAC) for technical assistance.

Agrichem, Pioneer Seeds, Pacific Seeds, Seed Distributors and Hylan Seeds for support of the summer crop programme.

The Forrests for the use of their sand dune and smiling through the down side of atrazine control of brome grass (it also does a fair job on wheat !).

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Field Peas and Fluid Phosphorus

Brendan Frischke,
SARDI, Minnipa Agricultural Centre

Location
Closest town: Streaky Bay
Co-operator: I & G Morgan

Rainfall
Actual annual total: 236mm
Actual growing season: 211mm

Yield
Potential: 1.2 t/ha

Paddock History
2001: Spray topped pasture

Soil
Grey highly calcareous sandy loam
67% calcium carbonate
43 mg/kg Colwell P

Diseases
Some Rhizoctonia.

Plot size
Small Plot - 6 rows x 15m
Replicates - 4

Other factors
Native wildlife damage.

Key Messages Box

- **Fluid P increased grain yield compared to granular P on calcareous soils.**
- **Nitrogen improves yields regardless of the fertiliser form.**

Why do the trial?

For several years now, fluid forms of phosphorus (P) have shown to be more efficient than granular forms of P in trials conducted on calcareous soils of Upper Eyre Peninsula. However most trials have tested fluid P on cereal crops. The aim of this trial was to evaluate the performance of granular and fluid P fertilisers in field peas on a highly calcareous soil.

How was it done?

Four fertilisers were applied to field pea varieties Kaspa and Parafield. Two fertilisers were granular and two were fluid fertilisers:

Di-Ammonium Phosphate (DAP - 18:20:0), granular

Triple Super Phosphate (TSP - 0:20:0), granular

Ammonium Polyphosphate (APP - 16:23:0*), fluid

Phosphoric acid (PHOS ACID - 0:26:0 %), fluid

*Note: APP concentrations are % w/vol rather than % w/w.

All fertilisers supplied a generous amount of P at 15 kg/ha. DAP and APP also supplied nitrogen at 13.5 kg/ha and 10.2 kg/ha respectively. TSP and Phosphoric acid supplied P only. Fluid fertilisers were diluted with water and applied at 150 L/ha. Parafield was sown at a target plant density of 45 plants/m^2 and Kaspa at 55 plants/m^2. Seeding depth was 2-4 cm.

What happened?

Field pea germination was very good because continual small rain events kept the soil moist early. Unfortunately, galahs thought so too and the trial became a popular dinner plate. Plant population was markedly reduced and some plots had severe damage. This sort of damage adds to the variation of growth and yield measurements and treatment effects can then be more difficult to determine. Visual damage scores were used to identify plots with excessive damage and remove them from analysis.

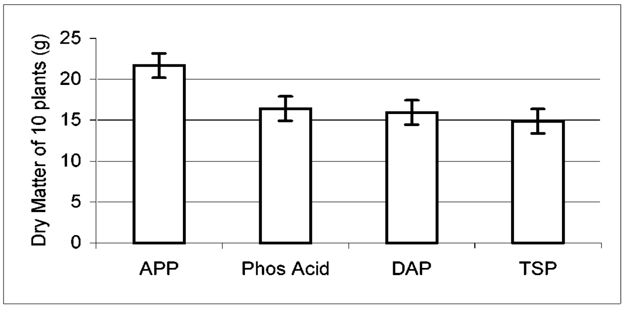


Figure 1: Dry matter of 10 pea plants at the beginning of flowering at Yandra, 2002.

Dry Matter

Fertiliser effects on dry matter production were measured by comparing the dry mass of ten plants sampled at random from each plot during flowering (Figure 1). APP produced 37% more dry matter than the other fertilisers. There was no difference in dry matter between phosphoric acid, DAP and TSP. Dry matter differences between varieties could not be determined because of different plant densities.

Grain Yield

The vine length of pea plants was very short due to poor seasonal conditions and hostile soils. Mechanical harvesting under these conditions would have led to variable grain losses that could bias results. Grain yield was measured by collecting all plants and grain by hand in 3 quadrats per plot to eliminate variable losses. Yields therefore may appear higher than expected. APP outyielded all other fertilisers by 17% - 33% (Figure 2). DAP was 20% higher than TSP, but this difference was significant only at P<0.1 (normally P<0.05). Fluids outyielded granular by 16% with or without N and applying N fertilisers increased yield by 25% for both fluid and granular fertilisers. On average across all treatments Kaspa yielded 0.68 t/ha compared to 0.50 t/ha for Parafield. Both varieties responded to the fertiliser treatments in a similar manner.

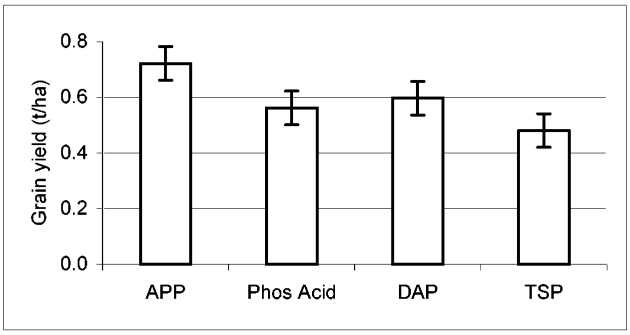


Figure 2: Grain yield of field peas versus fertiliser treatment at Yandra, 2002. Yields are the average of Parafield and Kaspa.

What does this mean?

Ammonium polyphosphate was more efficient on calcareous soils at Yandra, producing more dry matter and yield than other fertilisers used. DAP also outyielded TSP indicating fertilisers without N reduced the yield of field peas. Other research has indicated that field peas benefit from some starter N to help early growth (at Wudinna in 2002, 5 kg N/ha was sufficient). We can then speculate that if N was added to TSP or phosphoric acid, which both contain no N, yields would be higher from these fertilisers, but further trials are necessary to verify this.

There are too many variables and "what if" scenario's to attempt an economic analysis on the results of this trial and any fertiliser comparisons could be misleading. For instance the P rate used in this trial is much higher than district practice. This raises the question; would the yield differences between fertilisers be the same at lower P rates and/or if average yields were higher? For reliable economic comparisons of fertilisers, small trials or test strips need to be conducted on farm where normal granular P rates are applied.

Acknowledgments

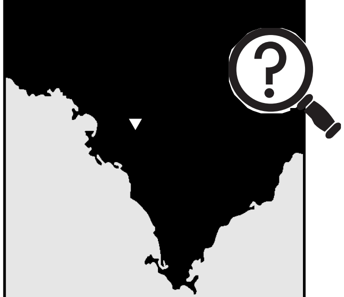
This work was funded by GRDC and SAGIT.

Thanks to Ian and Gladys Morgan for allowing access to their land for the purpose of conducting trials.

Alkaline Tolerant Lupins Update

Paul Lonergan[1], Jeff Paull[1] and Amanda Cook[2]

[1]University of Adelaide, Waite Institute; [2]SARDI, Minnipa Agricultural Centre



Location
Minnipa Agricultural Centre
Paddock South 5

Rainfall
Av. annual : 326 mm
Av. G.S.R.: 241 mm
2002 total : 278 mm
2002 G.S.R.: 219mm

Paddock History
2002: Pulse trials
2001: Excalibur Wheat
2000: BT Schomburgk Wheat
1999: Grass Free Pasture

Soil Type
Sandy loam, pH 8.9

Why do the trial?

The aim of the trials was to evaluate the performance of wild species of lupin on a calcareous soil. Varieties of cultivated lupin species *Lupinus angustifolius* (narrow-leaf lupin), *L. albus* (white lupin) and *L. luteus* (yellow lupin)) are well adapted for acidic to neutral soils. But on calcareous soils, symptoms resembling iron (Fe) chlorosis develop, resulting in severe grain yield reduction or even death. Two undomesticated species of lupin (*L. pilosus* and *L. atlanticus*), collectively referred to as rough-seeded lupins, have been shown to be tolerant to calcareous soils in glasshouse tests and preliminary field trials. These preliminary trials, conducted in 2001, showed reasonably good correlation between an early screening method and final yield. With multiplication of seed, the trial was expanded from single rows with 2 replications in 2001 to triple rows with 3 replications in 2002. Domestication of *L. atlanticus* is more advanced than that of *L. pilosus*, but it is *L. pilosus* which shows greater tolerance to high soil calcium carbonate ("lime"). Nevertheless, an additional small trial was conducted with 18 lines of domesticated *L. atlanticus* to observe their performance in a calcareous soil.

How was it done?

L. pilosus: A randomised complete block design was used with 15 genotypes covering a range of tolerances as previously measured in soil and solution tests. There were 3 replications of each genotype. The plots were 2 m long x 3 rows wide.

Domesticated *L. atlanticus*: Eighteen lines of domesticated *L. atlanticus* were randomised within a block containing a double grid of 2 wild atlanticus lines (one tolerant, one intolerant as measured in previous pot experiments). Each plot was a single row, 2 m long.

What happened?

L. pilosus: Analysis of variance showed a significant difference in yield between lines, however the correlation with previous measurements of tolerance was poor. This was due to the combination of an unusual season and wide ranging maturities among the genetic material used. Late rains had an impact on the final yield of early genotypes, particularly the early, tolerant genotypes. Figure 1(a) shows a non-significant correlation between yield and tolerance index (0 = most tolerant; 4 = most intolerant) of early maturing genotypes while Figure 1(b) shows a significant correlation for the same variables among the later maturing genotypes.

L. atlanticus: The domesticated lines performed poorly against both the tolerant and intolerant wild types (Figure 2). This was not totally unexpected as earlier glasshouse tests had displayed symptoms similar or worse compared to the intolerant wild type. Interestingly, the intolerant genotype outperformed the tolerant one. These results can again be explained by late rains which would have increased the yield of the late maturing, intolerant control while having little effect on the earlier maturing, domesticated lines and tolerant control.

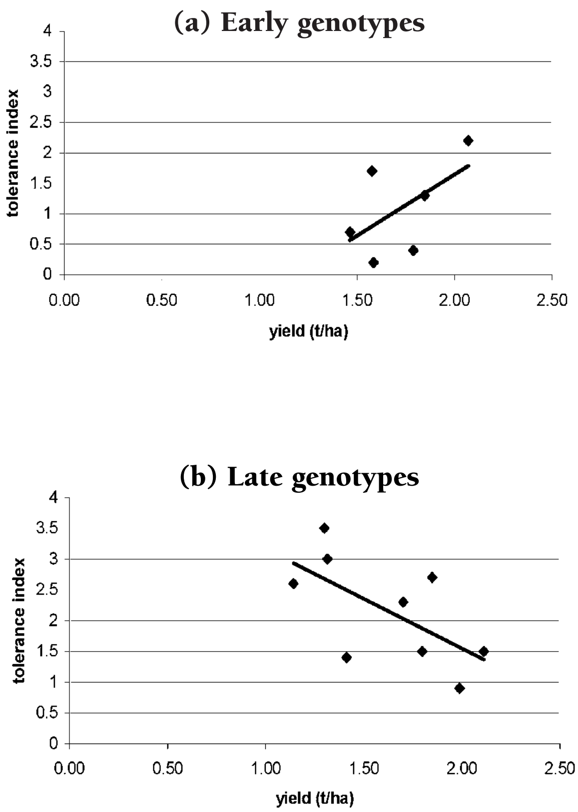


Figure 1: Relationship between grain yield and tolerance to calcareous soils in L. pilosus lines at Minnipa in 2002. (a) Early genotypes - r value not significant. (b) Late genotypes - r value significant.

Break Crops

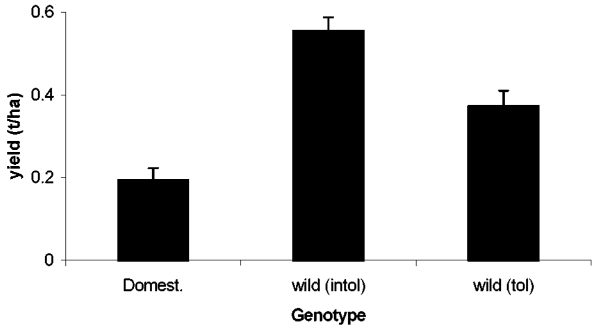


Figure 2: Grain yield of domesticated L. atlanticus compared to lime tolerant and intolerant wild types, at Minnipa in 2002.

What does this mean?

The 2002 season was not ideal for identifying tolerance of lupins to calcareous soils but after taking maturity into consideration, the yield results show reasonable correlation with early stage glasshouse testing. This was especially the case among the later maturity group where the more tolerant lines produced the highest yields. In addition, the presently available domesticated lines of lupins are not suitable for growing on calcareous soils but further breeding, particularly domestication of the pilosus lines could result in an alternative break crop for farmers.

Acknowledgements

Thanks to Leigh Davis, Willy Schoobridge and Lisa Bennie for assistance with trial work and to Bevan Buirchell (WA Department of Agriculture) for supplying seed of the domesticated *L. atlanticus* lines. This work was funded by GRDC, SAGIT and SARDI.

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Key to symbols

Section

3

Section Editor: Tim Richardson

SARDI, Field Crop Evaluation Unit,

Port Lincoln

Pastures

Legume based pastures remain an important part of the cropping rotation in low rainfall environments. They provide a low risk break option and with the improved wool and meat markets, the importance of establishing and maintaining quality pastures has increased.

Generally pastures during the 2002 season were characterised by poor vegetative growth but surprisingly good pod set. There was little aphid activity and a considerable amount of spray topping.

Trial work on Eyre Peninsula is currently concentrating on evaluating alternative pasture legumes, lucerne establishment and productivity, Sulfonylurea tolerant medics and grazing native pastures.

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UNITED GROWER HOLDINGS

UGH

Location
Balumba
Closest town: Kimba
Cooperator: Rob, Lyn, Damien and Shane Jericho
Group: Million Hectare for the Future

Lucerne - Get it Right and the Rewards are Great

Linden Masters,

Rural Solutions SA, Field Crop Agronomist at Cleve

Key Messages Box

- **Risk management. Don't take short cuts.**
- **Demonstrating effects on lucerne establishment.**
- **Establish a variety comparison trial in a typical farm situation.**
- **Correct pre establishment preparation is essential.**
- **In hindsight sowing into a stubble would have helped early cover crop removal.**

Why do the trial?

There is little lucerne grown on Upper and Eastern Eyre Peninsula since aphid attacks in the 70's and the new generation of farmers are not familiar with the establishment and economic benefit of growing lucerne. This trial was conducted to encourage the uptake of lucerne through demonstration trials and support. A site was chosen to represent a typical district soil type, consisting of sand over clay, including a non-wetting parallel dune. A series of Challenge 2020 Lucerne workshops have been conducted to encourage best practice and success in Lucerne establishment. Questions arose on what variety to plant, as there has been little comparison of varieties on Eyre Peninsula.

This 35 hectare site allowed the flexibility of including a SARDI Breeder Line evaluation variety trial and a farmer type variety comparison using available equipment. It is intended that the whole area will be then conventionally managed giving an on farm comparison of different varieties.

How was it done?

It is essential that good weed control occurs prior to sowing and this was achieved by using an autumn tickle to stimulate weeds, which were predominately medics and then a glyphosate knock down prior to sowing. On June 18, 21 mm of rain gave ideal soil conditions. A Scariseeder with 4" points and finger tyne harrows was used to incorporate Trifluralin @ 1.2 L/ha, with a cover crop of 40 kg/ha of Krickauff wheat and 70kg of 28:13:00 fertiliser. Sceptre lucerne which has a winter activity rating of 7, was immediately sown at 5 kg/ha with a 12 volt spreader into a grass free pasture paddock and incorporated using a Woolford diamond prickle chain.

A SARDI breeder line evaluation trial of 30 varieties in 100 plots was sown using a cone seeder with press wheels. Another section was sown on a broader farm scale, using a 12 volt spreader, 2 runs x 10 metres in width comparing Sceptre, Eueka, Super Seven and Super 10 lucerne varieties.

Insect control consisted of a seed dressing on all but the trial plot and the site required a further spray for redlegged earthmite and cutworm.

The cover crop was eventually taken out using a grass herbicide, the wheat crop was harvested in December averaging 0.82 t/ha and a plant count in January revealed 2-3 plants/m^2.

What happened?

Germination exceeded the target of 20 plants/m^2 and the season looked great until early August. The following months of decile 2 rainfall, combined with continual severe wind events severely impacted lucerne development. It was recommended that the cover crop be removed and much discussion took place on when to remove the cover crop. District opinion was that in previous years you could grow both lucerne and the cover crop, but the cover crop removal was delayed to the detriment of the lucerne. When a grass herbicide was finally used in the wheat crop's early dough stage, it was much too late for the survival of the juvenile lucerne plants, resulting in establishment rates of 2-3 plants/ m^2

These establishment rates were also significantly influenced by insect damage. Even though the farmer's seed was coated with an insecticide, the paddock still needed to be sprayed due to a severe attack of cutworm and RLEM and the breeder line evaluation trial which used untreated seed, experienced greater reductions in establishment at approximately 40%.

What does this mean?

After starting so well it was disappointing for all concerned to see such a poor result. The clearest result from this work is that you need to treat the establishment of lucerne as the main crop, rather than having a bob each way and both failing.

It is important that emphasis is placed on ensuring the lucerne establishment is successful, allowing the farmer to capitalise on the high input costs that will stand in good stead for the next 5-10 years.

Previous years experience has shown the necessity to have cover in establishment, to ensure that the land and the small plants are protected. A decision needs to be made if a standing stubble is sufficient or a combination is needed? At one property where the stubble had been pulverised and sown late with a cover crop, substantial soil erosion occurred.

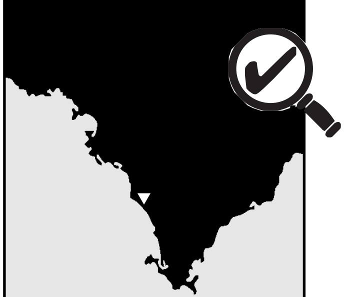
Risk management is paramount in drought years or years with a poor rainfall spread and season like 2002 with horrific winds and insufficient rain complicated decision-making. This year allows us to further strengthen our resolve to successfully establish lucerne in a range of seasons.

When attempting to establish lucerne the main take home messages are

- It is essential to remove the cover crop.
- Insect control is critical, monitor closely and take no short cuts.
- Follow the seven steps in the "Success with Lucerne" manual section 3.4.

Acknowledgements

Rob, Lyn, Damien and Shane Jericho. The Minnipa sowing team, SARDI pasture group and The Million Hectare project



Location
Closest town: Elliston
Cooperator: Arthur and Veronica Robinson, Simon Guerin, Steve McCracken.
Group: Eye Peninsula Natural Resource Management Group, Elliston Landcare Group

Rainfall
Av. Annual total: 427 mm
2002 total: 355mm
2001 total: 399

Soil
Land System: Undulating calcrete plains
Major soil type description: Shallow soils over sheet calcrete

Native Grassland Grazing Demonstration Sites

Brett Bartel,

Rural Solutions SA

Why do the trial?

Native grasslands are one of the most threatened native ecosystems in Australia. On Eyre Peninsula approximately 448 000 ha of land is likely to have native grass based pastures and the value of native grasses for improving pasture productivity from non-arable land is beginning to be recognised. Through adopting alternative grazing strategies enormous opportunity exists for improving both the productivity, biodiversity and conservation value of this land.

Unfortunately there is very little quantitative information about best management options for grassy ecosystems. We do know that set stocking and overgrazing, result in the degradation of native species. Palatable native grasses, herbs and forbs are continually selected by livestock and over grazed until they are removed from the systems. As a result less palatable introduced species, such as saffron thistles, thread iris and wild oats, become dominant.

This project aims to demonstrate that improved grazing strategies can increase productivity, whilst enhancing the ecological values of native grasslands and collect quantitative data to support the theory.

This project was first outlined on page 149 of the 2000 Eyre Peninsula Farming Systems Summary.

How is it done?

Three sites have been established on Western Eyre Peninsula to demonstrate best practice grazing strategies, where paddocks have been subdivided and watering points modified to allow for improved grazing management (rotational grazing). Paddocks are grazed at high stocking rates between 25 and 100 DSE per ha for short periods of time (ideally less than two weeks). The perennial native grasses are allowed to recover before being re-grazed. The total carrying capacity of the site will not be lowered, however stock pressure will be concentrated into shorter periods of time.

At each site scientific monitoring is being undertaken to collect quantitative data to support changes in pasture composition and productivity. Within each paddock permanent 100 metre long transects have been established. Along this transect measurements are taken every 4.5 metres using a 50 x 50 cm (0.25m^2) quadrat. At every monitoring the exact location of each quadrat will be revisited to get an accurate measure of changes in the pasture over time. Control transects which reflect traditional grazing management were established outside the trial site to allow comparisons. The following observations are being monitored at each site:

- **Presence/absence** - of plant species gives an indication of the frequency and diversity within the pasture and monitoring will determine if this is changing with modified grazing strategies.
- **Contribution of dominant species to the pasture** - the Botanal monitoring program is used to determine the contribution of the dominant plant species to the total dry weight of the pasture.
- **Available pasture mass** - pasture cuts will be undertaken to determine pasture height/weight relationships. This will be used to determine appropriate stocking rates.
- **Number of native perennial grass plants per quadrat** - will give an indication of the condition of the pasture as perennial grasses provide stability to the grassland.
- **Photo points** - will be established to monitor visual changes in the pasture.
- **Stocking rates** - landholders are monitoring stocking rates to determine DSE rating and productivity of the pasture.

Initial monitoring at these sites started between October 29 and November 1, 2001, with subsequent measurements observed from October 21-23, 2002. Subject to funding, continued monitoring will be undertaken yearly in spring.

Demonstrations similar to these are being undertaken in the Mid North and Eastern Mount Lofty Ranges.

What happened?

The following is a summary of the results from Arthur and Veronica Robinson's site near Elliston.

The overall stocking rate for the trial site was 1.17 DSE per ha. This is similar to previous seasons and the district average, however stock pressure was concentrated into a much shorter period.

The most frequently occurring species were introduced annual medics and grasses and Spear grass was the most dominant native grass (refer Table 1). It is thought that over time the frequency of native species will increase due to continued improved grazing management.

Table 1: The most frequently recorded species, ranked on presence/absence monitoring.

RANKING	COMMON NAME	BOTANICAL NAME
1	woolly burr-medic	*Medicago minima
2	wild oat	*Avena fatua
3	red brome	*Bromus rubens
4	barrel medic	*Medicago truncatula
5	annual cat's-tail	*Rostraria cristate
6	thread iris	*Gynandriris setifolia
7	spear-grass	Stipa sp.
8	silver grass	*Vulpia bromoides
9	fern grass	*Desmazeria rigida
10	Lincoln weed	*Diplotaxis tenuifolia
11	rusty spear-grass	Stipa eremophila
12	saffron thistle	*Carthamus lanatus
13	hare's ear	*Bupleurum semicompositum
14	Cretan weed	*Hedypnois rhagadioloides
15	barley grass	*Horduem leporinum
16	tall spear-grass	Stipa nodosa
17	hairy sheepweed	*Neatostema apulum
18	hop clover	*Trifolium campestre
19	wallaby-grass	Danthonia sp.
20	bulbous meadow-grass	*Poa bulbosa
21	common wallaby-grass	Danthonia caespitosa
*** Indicates introduced species**		

Table 2: Percentage contribution of plant groups to total dry weight of pasture (Botanical monitoring).

PLANT GROUP	PADDOCK 1		PADDOCK 2		PADDOCK 3		PADDOCK 4		PADDOCK 5		PADDOCK 6		CONTROL	
	Nov-01	Oct-02	Nov-01	Oct-02	Nov-01	Oct-02	Nov-01	Oct-02	Nov-01	Oct-02	Nov-01	Oct-02	Nov-01	Oct-02
Annual grass weeds	38.8	48.5	96.5	88.3	17.6	1.6	65.3	86.6	4.6	0	71.1	65.4	79.4	93.9
Native grasses	0.2	17	2.9	4	18.6	58	0.5	4.7	20	74.5	0.6	19.2	0.3	4.9
Annual broad leaved weeds	34.2	31.4	0.3	7.1	30.9	39.4	3.3	5.2	10.8	21.6	4.8	3.4	17	0.1
Medics/Clovers	26.8	3	0	0.3	29.3	0.2	30.4	2.8	58.7	0	23.5	2.3	3.3	0.9
Perennial weeds	0	0	0	0	3.5	0.8	0.5	0.5	6	3.9	0	9.8	0	0
Native herbs and forbs	0	0	0.2	0.4	0	0	0	0	0	0	0	0	0	0
Total dry matter (t/ha)	1.50	0.89	1.82	1.36	1.03	1.02	2.42	2.29	1.20	0.87	1.37	1.67	2.17	1.60

Table 2 illustrates the contribution of each plant group to the total dry weight of the pasture. Individual species from the Botanical monitoring have been grouped into functional groups to illustrate which plants are dominant in the pasture. In both years introduced annual grass weeds dominated the pasture and the contribution of native grass varied dramatically between paddocks.

Across all paddocks an increase in the contribution of native grasses to the pasture was observed (Table 2) and interestingly this was consistent with the control paddock. It is believed that with continued improved grazing strategies native grasses will continue to contribute more to the pasture biomass and weed species will reduce.

The total feed on offer was slighter less in most paddocks in 2002 than 2001 (Table 2) and the rainfall in 2002 (355 mm) was slightly lower than 2001 (399 mm). This combined with better feed utilisation could explain the drop in the feed on offer.

What does this mean?

Trends in this data are difficult to interpret due to the limited number of comparisons. It is difficult to determine if changes in data are a result of grazing strategies or seasonal variations.

Changes in grassy ecosystems as a result of improved management are likely to be long term and little quantitative information has arisen from the first two years of monitoring. Continuous long term monitoring is required to establish baseline information and to determine if management strategies will result in positive change.

It is predicted that with improved grazing management the frequency and contribution to pasture biomass of native species, in particular native grasses, will increase. Consequently annual weed species should reduce due to competition from perennial native grasses.

Acknowledgements

This project is funded by:

- WWF Grassy Ecosystems Grants through the Eyre Peninsula Integrated Natural Resource Management Group.
- Natural Heritage Trust
- Department of Land Water and Biodiversity Conservation.

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The Department of Water, Land and Biodiversity Conservation

Natural Heritage Trust
Helping Communities Helping Australia

Location
Minnipa Agricultural Centre

Rainfall
Av. Annual total: 326 mm
Av. Growing season: 241 mm
2002 total: 278 mm
2002 GSR: 219 mm

Soil
Calcareous red sandy loam
pH 8.9

Location
Walpeup, AgVic

Rainfall
Av. Annual total: 337 mm
Av. Growing season: 227 mm
2002 total: 158 mm
2002 GSR: 82 mm
(April/October)

Soil
Red sandy loam
pH 8.4

Further Information
Jake Howie, Waite Campus
Phone (08) 8303 9407

Sulfonylurea Tolerant Medic

Jake Howie[1], Ian Creeper[2] and Ron Sly[3]
[1]SARDI Pastures Group, [2] formerly Minnipa Agricultural Centre and [3]Walpeup

Key messages

- **A new medic is showing good tolerance to sulfonylurea herbicide residues**
- **Herald (and other medics in general) can be very sensitive to sulfonylurea residues**

Why do the trial?

To assess the tolerance of a new mutant strand medic line to sulfonylurea herbicide (SU) residues.

A new annual medic "FEH-1" has been bred from Herald strand medic using mutation breeding by John Heap (SARDI) and Chris Preston (CRC for Weed Management Systems) as part of a GRDC-funded project. Annual medics are normally extremely susceptible to even very low residues of SU herbicides (eg < 1 part per billion!) resulting in severe stunting, reduced dry matter production, seed yields, persistence and N fixation. There is also an increase in seedling mortality, and susceptibility to root diseases and nutrient and moisture stresses. However FEH-1 appears to have good tolerance to the residues of a range of SU herbicides, including triasulfuron and chlorsulfuron and it is being evaluated extensively at low rainfall/alkaline soil sites for potential release as a new annual medic cultivar (EPFS 2001, p56).

How was it done?

Chlorsulfuron and triasulfuron was applied at 10, 20 and 40 g/ha and 15, 30 and 60 g/ha respectively (i.e. 50, 100 and 200% full label rates) to plots in May 2001 at sites in Minnipa, SA; Walpeup, Victoria and Kingsthorpe, Queensland. Herald and FEH-1 were then hand sown as single spaced seeds into these plots with SU residues in June 2002. Measurements taken during 2002 included nodulation, root and shoot growth in late August and shoot growth in September (and early October at Minnipa).

What Happened?

At Minnipa FEH-1 showed good tolerance to increasing rates of SU herbicide (Fig. 1). Herald production on the other hand was generally reduced with increasing rates

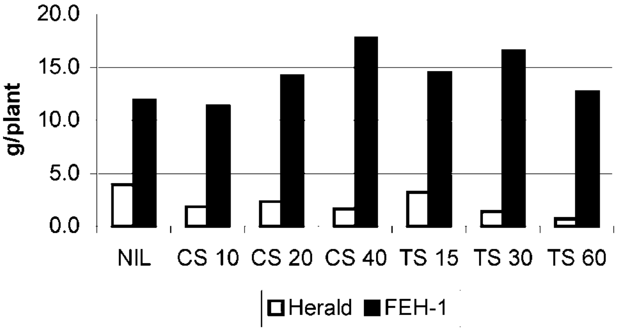

Figure 1: Shoot Dry Matter on SU Residues -= Minnipa 2/10/02

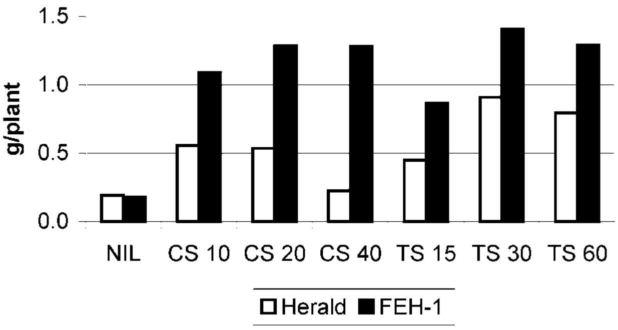

Figure 2: Shoot Dry Matter on SU Residues - Walpeup 24/09/02

of herbicide. The big mystery for us is the inexplicable difference between FEH-1 and Herald in apparent absence of herbicide ('Nil' controls), especially when after 11 weeks there were no measurable differences between them. So what happened in the intervening 6 weeks? We are fairly confident there was no plot contamination from our application; the paddock had no record of recent SU use and plant tissue analysis revealed nothing exceptional. However way back in 1994, metsulfuron methyl was applied at 7g/ha. Is it possible that after all this time there are still SU residues which are having an impact on susceptible plants as their roots explore soil at greater depths? (nb. This phenomenon was also noted at Walpeup, EPFS 2001, p.56) Alternatively there may be other differences between Herald and FEH-1 than we are as yet unaware of.

At Walpeup, as in 2001, not only did FEH-1 appear to be quite tolerant of the various simulated levels of SU residues (Fig. 2) but it also responded very positively to the presence of residues. We presume this once again to be a result of the residual weed control provided by the herbicide and thus reduced competition for moisture and nutrients in what was an exceptionally dry year at Walpeup. Although good early weed control was exercised, there was a subsequent germination of soursob, ryegrass and some mustard. This was suppressed to varying degrees by the residual SU herbicide in the treated plots and probably had a marked effect on moisture availability. However unlike last year when Herald diminished with increasing rates of residual herbicide, this year Herald actually responded positively to herbicide application, albeit less so than FEH-1. This ties in with the observations of some Mallee farmers that medic pastures can be very good after triasulfuron.

Figure 3: The impact of 15g of Logran® on the shoot and root growth of Herald and FEH-1 Medic.

What does this mean?

- The results for FEH-1 continue to be exciting and follow on from the very encouraging Walpeup 2001 results.
- There is potential for a SU tolerant medic to greatly benefit from the residual weed control of SU herbicides.
- Maybe the effects of SU residues are much longer lasting in some cases and more profound than initially thought.

What now?

A submission has been made to GRDC to continue this work further in 2003 and beyond. Additional SU residue sites at Minnipa, Walpeup and Kingsthorpe have been set-up for further experimentation with FEH-1 in 2003. These have a greater range of residue levels (25 - 400% label rates) and include metsulfuron-methyl (eg Ally) for the first time.

We will also be evaluating the agronomic performance of FEH-1 (cf. Herald and Harbinger) in the absence of SU residues to confirm that it still retains Herald's (and Harbinger's) overall good adaptation to low rainfall alkaline sandy loams. This will be done in swards for the first time and measurements will include dry matter production, days to flowering, pod and seed yields and regeneration.

We are also liaising with John Matthews (University of Adelaide) in assessing the potential role of FEH-1 as part of an integrated systems approach to control branched broomrape (Orobanche ramosa) in which SU herbicides are used in-crop and are followed with highly competitive, dense medic pastures (eg FEH-1).

Acknowledgements

The funding of J. Heap's PhD studies by GRDC (JRF 46) is gratefully acknowledged, as is the valuable assistance provided by Peter Schutz, SARDI.

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Key to symbols

Location
Mangalo
Rob and Sue Norris
Franklin Harbour Ag Bureau

Rainfall
Av Annual : 350 mm
Av G.S.R. : 250 mm
2002 total : 210 mm
2002 G.S.R.: 164 mm

Paddock History
2001 : Wheat
2000 : Pasture
1999 : Wheat

Soil Type
Shallow acidic red mica schist loam

Plot Size
10m x 2m x 3 reps

Other Factors
Deep Sowing , Sowing Time , Dry Season

Alternative Legume Pastures

Ian Creeper[1], Neil Cordon[2] and Jake Howie[3]
[1]formerly SARDI , Minnipa Agricultural Centre, [2]Extension Agronomist EP Farming Systems Group, Minnipa Agricultural Centre, [3]SARDI, Pastures Group.

Key Messages

- **Promising alternative pasture legumes are in the pipeline.**
- **More evaluation needed on alternative pastures in a range of seasons, soil types and rotations before widespread sowings are conducted.**
- **Farmers need to carefully consider the characteristics of a new pasture species for their farm and try a small area first.**

Why do the trial?

In the low rainfall zones of Eyre Peninsula the risks associated with pulse and canola crops within the rotation are considered too high. In many cases the only viable 'break" option is a legume based pasture which has traditionally been medic, however there has been an explosion of new pasture species which need to be evaluated on Eyre Peninsula especially on the slightly acidic soil types.

How was it done?

A range of pasture species was sown on June 4, 2002 at various seeding rates depending on the species. A post emergent spray of Targa® @ 300 ml/ha and Broadstrike® @ 25 g/ha was applied.

The plots were visually assessed for pod set and dry matter production in October. The site was not grazed.

What happened?

Deep sowing delayed emergence with vetch the first to germinate, however by the season end the level of growth and plant numbers was quite good.

Table 1: Pasture Legume Performance (Good=5, Poor=1)

Variety	Pod Set	Late Dry Matter Score
Caliph Barrel Medic *	4	4
Parabinga Barrel Medic *	4	3
Paraggio Barrel Medic *	4	3
Cavalier Burr Medic *	5	4
Jester Barrel Medic *	5	4
Trigonella balansae *	4	4
Mogul Barrel Medic *	5	5
Frontier Balansa Clover	3	4
Casbah Bisserula	3	4
Prima Gland Clover	5	4
Dalkeith Sub Clover	1	1
Orion Sphere Medic	5	4
Cadiz Serradella	2	3
Charano Serradella	4	5
Herald Strand Medic	4	2
Toreador Disc/strand Medic	5	4
Scimitar Burr Medic	5	2
Rose Clover	5	3
Morava Vetch	4	4
Septre Lucerne	0	2
Super 10 Lucerne	0	1

**not inoculated*

These were not harvested due to seasonal conditions, however we plan to measure the regeneration and dry matter production in 2003.

What does this mean?

Not a lot can be determined from this data except that even under adverse seasonal and management conditions most of the pasture species produced some growth and seed set. From previous work throughout SA, annual medic still appears to be the best legume pastures option for the low rainfall, neutral/alkaline soils, with the best adapted varieties being Herald, Caliph and Toreador. At this site some of the medics were at a disadvantage through not been inoculated, however it is worth noting the good visual performance of Mogul barrel medic.

With increasing rainfall the mid-season barrel medics will have a role and as the pH(water) drops to say 6.0, then the more acid tolerant burr medics such as

Santiago, the new Cavalier and Scimitar and Orion sphere medic may do well. Cavalier and Scimitar are significantly softer seeded than Santiago and so should regenerate more densely in the year after seed set.

Also worth watching is the new Prima Gland Clover, which is suited to a broad range of soil types and pH , over 375mm rainfall and has excellent resistance to red legged earth mite.

Selection of a Lucerne variety depends on a lot of factors such as it's role in the rotation, degree of winter activity and type of rotation planned.

When selecting a balansa clover the cultivar Frontier seems to be the best adapted, whilst good old vetch's dry matter production is rarely beaten by the other forage pasture species such as serradella or bisserula.

Acknowledgements

This work was funded by GRDC, SARDI and SAGIT and would have not been possible without the assistance of Wade Sheppard, MAC and Linden Masters, Field Crop Consultant, Rural Solutions SA. Thanks to Rob and Sue Norris for their cooperation during the year.

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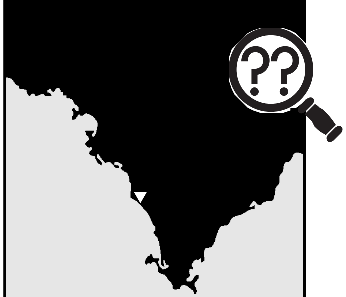

Location
Closest town: Elliston
Cooperators: 16 farms

Group
Elliston Sheep Producers Group

Mineral deficiencies in sheep

Brian Ashton,

Senior Livestock Consultant, Rural Solutions SA, Pt Lincoln

Key Messages

- **Copper and cobalt deficiency can cause poor health in sheep and cattle if left untreated.**

Why do the trial?

Sheep are a vital part of farm businesses in the Elliston district. These farmers have been concerned about the health of their young sheep. All of the farmers in the Elliston Sheep Producers Group currently give mineral supplements to their sheep (eg. mineral blocks, copper in water, mineral drench, B12 injections and bullets - in various combinations) but they wondered if they were giving enough of the right treatments at the right time.

How was it done?

The Elliston Sheep Producers Group obtained funding to investigate overall animal health - minerals results presented here are only part of the project. Other areas are worm control and nutrition over the first summer.

All group members filled out a survey outlining their current management practices and level of production. Blood samples were taken from sheep during spring. In each mob, 5 good sheep and 5 poor sheep were sampled. Some farmers learnt to take the samples themselves.

What happened?

- Selenium levels were good in all cases
- Copper levels were OK in all but one case.
- Cobalt levels were low unless the sheep had been treated.

The recommended cobalt treatment for sheep is a Vitamin B12 injection at marking and a cobalt bullet at weaning. However, some lambs were already deficient at lamb marking, causing a serious setback. After the B12 injection the lambs may become deficient again before they are big enough for a bullet, so they may need a second B12 injection.

Current copper treatments, and good copper fertilizer history appear to be sufficient.

Health monitoring of the sheep will continue.

Acknowledgments

- Meat and Livestock Australia (MLA) for $10,000 under a Producer Initiated Research and Development (PIRD) program.
- The funds enable Brian Ashton to be contracted as consultant to the group.

PIRSA RURAL SOLUTIONS

Table 1: Example of results from sheep blood tested at Elliston in September 2002

Farm	Situation	Selenium	Copper	Cobalt (B_{12})	Key finding
	Normal	50 to 550	7.5 to 20	400 to 7000	Below these levels production losses occur
Farm 1	Lambs, at marking (in worst paddock on farm)	157	16	110	Cobalt problem in bad paddocks by marking time
Farm 2	Lambs, treated 3 weeks earlier with cobalt bullets	370	18	2122	Cobalt bullets work very well
Farm 2	Lambs, from mob above not given bullets	200	21	409	Cobalt bullets work very well
Farm 3	Hoggets, given bullets at weaning a year earlier	228	15	4964	Cobalt bullets work very well
Farm 3	Poor hoggets, from the same mob	252	16	304	They may have lost their bullets (?)
Farm 4	Weaners given B_{12} injections seven weeks earlier	259	17	283	B_{12} injections don't last long
Farm 5 (tested in January)	Lambs not treated and looking poor	495	17	786	Deficiency not as likely to show in blood test in summer

Section
4

Section editor: Mark Habner

Rural Solutions SA, Streaky Bay

Field Crops Consultant

Rotations

Selecting the sequence that different crops are sown in following years is one of the most important management issues for a profitable and sustainable farming system. It's an opportunity to think strategic - to look at the big picture and set up the balance and direction that your farm is heading.

This section looks at a number of different rotations that have been used and evaluates how they are doing in terms of providing a disease break, soil fertility, water use and for on-going sustainability in the system - profitability.

It is the hope of this section editor that the information provided will contribute to on-farm decision making.

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Location
Closest town: Rudall
Cooperator: Matt & Mignon Dunn

Rainfall
Av. Annual total: 344 mm
Av. Growing season: 254 mm
Actual annual total: 301 mm
Actual growing season: 199 mm

Yield
Potential: 1.78 t/ha
Actual (average all treatments): 1.05 t/ha

Soil
Land System: Dune-Swale
Major soil type description: Shallow grey sandy-loam over calcrete rubble

Plot size
45m x 19m

Wheat After Legumes: Too Much N?

Damien Adcock,
University of Adelaide, Roseworthy

Key messages

- **Large amounts of nitrogen (N) were available in the soil at the beginning of the season following a medic pasture or green-manured vetch.**
- **Too much soil N increased pre-anthesis dry matter production and water use, exposing the cereal crop to drought stress reducing yield.**

Some background

Although the benefit of medic pastures, mainly through improved soil N availability to the following cereal crop, is well documented, anecdotal evidence often suggests that the yield performance of the first wheat crop after a medic pasture is poor. However, there is little actual data, particularly for the Upper Eyre Peninsula, to assess the extent to which cereals perform poorly the first year after a medic pasture when compared to an alternative rotation. General explanations offered for this poor yield performance include disease carry over, particularly Pratylenchus and Rhizoctonia, use of subsoil moisture in the medic phase reducing soil water availability for the following the cereal crop. Additionally, the abundant amounts of soil N available to wheat after medic pastures may cause 'haying-off' (premature ripening of cereal crops in conditions of post-anthesis drought).

This article will provide data suggesting that a key factor in the observed poor yield performance of wheat after medic in a low rainfall environment is the N input from the legume phase of the rotation, and that options to manage this N need to be carefully considered.

How was it done?

The rotation trial was established in 1999, near Rudall on eastern Upper Eyre Peninsula, to compare the performance (yield, grain quality, water use and water use efficiency, N economy) of wheat in a series of two-phase rotations. The rotations were barley-wheat (BW), canola-wheat (CW), medic pasture-wheat (MW), continuous wheat (WW) and vetch-wheat (VW). Medic pastures were not grazed and vetch was green manured (desiccated and retained on surface). Each treatment (rotation) was replicated four times in a randomised block design. In 2001 a zero (70 kg TSP/ha) or district practice (70 kg DAP/ha, 12.6 kg N/ha) nitrogen sub treatment was incorporated into each plot.

Soil Information

Plant available water capacity (FC - PWP) at the site is only 127mm based on an effective rooting depth of 70 to 80cm, although this amount does not consider physical or chemical limitations to root growth and/or the efficiency of roots to extract soil water at depth. The chemical profile of the soil changes considerably at this depth, making the subsoil quite hostile. It has high extractable boron (>10 mg/kg), decreased exchangeable calcium (good for soil structure), increased exchangeable sodium (sodicity and/or salt) and very high pH (>8.5 in $CaCl_2$).

What happened?

The amount of potentially available soil nitrate (NO3-) in the soil profile prior to sowing in 2002 is presented in Table 1.

Table 1: Soil nitrogen (kg NO_3^-/ha) prior to sowing.

2001	2002	0-10 cm	10-20 cm	20-40 cm	40-60 cm	60-80 cm
Barley	Wheat	40	14	6	16	11
Canola	Wheat	133	10	16	7	21
Medic	Wheat	144	50	29	29	16
Vetch	Wheat	227	49	34	11	35
Wheat	Wheat	33	41	18	19	24

Clearly, large amounts of N, present as soil nitrate-N in the surface soil layer (0-10cm), were conferred by the preceding medic, vetch and canola phases of the rotation treatments.

Dry matter (DM) accumulation for wheat after medic (MW) receiving zero N, compared to continuous wheat (WW) for both N treatments is shown in Figure 1.

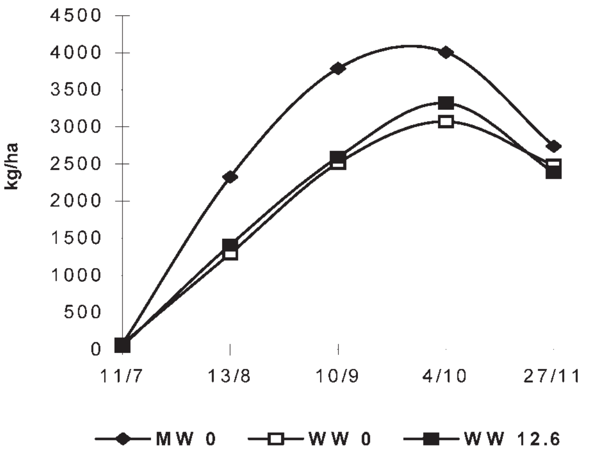

Figure 1: DM accumulation (kg/ha) for wheat following medic and continuous wheat rotations.

Amounts of nitrogen in shoot dry matter of wheat at tillering (13th of August) was greater in the legume-cereal than the continuous cereal rotations (Table 2). The application of 12.6 kg N/ha did not increase the nitrogen content of shoots however it caused a slight increase in the leaf area index. All measures of LAI were much less than 2.5, a level suggested in literature to significantly reduce soil evaporation. So the effect of these differences in LAI on soil evaporation is questionable. Indeed, Yunusa et al. (1993) suggested that soil evaporation is relatively insensitive to canopy development under infrequent rainfall and windy conditions. Such conditions are frequently experienced on Upper Eyre Peninsula.

Table 2: Shoot nitrogen (kg N/ha) and leaf area index at tillering (13/8).

Crop		Shoot Nitrogen	Leaf Area Index	
2001	2002		No Nitrogen applied	12.6 kg N/ha applied
Barley	Wheat	46 a	0.62	0.91
Canola	Wheat	84 b	0.95	1.30
Medic	Wheat	106 c	1.28	1.69
Vetch	Wheat	101 bc	1.33	1.86
Wheat	Wheat	45 a	0.55	0.72
LSD (P=0.05)		17.2		

Water use is intrinsically linked to crop transpiration, which is related to LAI. The difference in LAI between MW and WW resulted in development of soil profiles with different volumetric water contents (Figure 2).

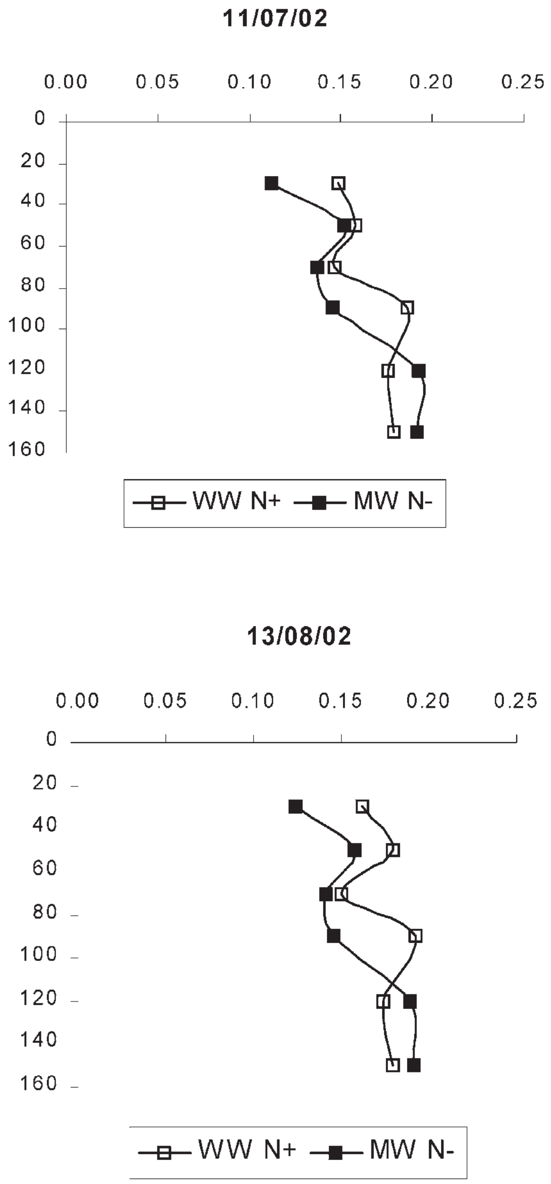

Figure 2: Volumetric water content for soil under wheat after medic (MW) and continuous wheat (WW), at the 3-leaf stage (11/7) and tillering (13/8).

Between the 3-leaf stage and tillering, wheat following medic used more soil water from the 30 and 50cm soil layers compared to the continuous wheat. More water was available below 70cm in wheat after wheat than wheat after medic, suggesting the lower water use of wheat after wheat may result in greater losses of soil water below the effective rooting depth of 70cm. The slight increase in volumetric water content in the 30cm soil layer for wheat after wheat suggests that rainfall exceeded evapotranspiration from the 3-leaf stage to tillering. In comparison the volumetric water content for wheat after medic in the same layer remained relatively unchanged, suggesting the crop was already relying on follow up rainfall for continued growth.

The effect of rotation on wheat grain yield and quality for 2002 is shown below (Table 3). The grain yield of wheat following barley was greater than for any other rotation treatment. Wheat after legumes had the lowest yields although the reduced yield of wheat following vetch suggests that the poor performance of wheat is not particular to medics. Furthermore, wheat after canola also yielded less than after cereals. The addition of 70kg DAP/ha (12.6 kg N/ha) did not affect grain yield or quality in any rotation.

Table 3: Yield and grain quality data for wheat in 2002 (average of 0 and 12.6 kg N/ha sub-treatments).

2001	2002	DM* (kg/ha)	Grain (t/ha)	Protein (%)	Screenings (%)	Test Wt. (g/hL)
Barley	Wheat	1499 ab	1.31 a	11.96 c	2.05 bc	76.32 a
Canola	Wheat	1474 ab	1.11 bc	15.60 b	1.62 c	76.20 a
Medic	Wheat	1700 a	0.98 c	18.18 a	1.97 bc	74.40 a
Vetch	Wheat	1099 c	0.66 d	18.64 a	3.72 b	73.53 b
Wheat	Wheat	1271 bc	1.17 b	11.71 c	2.40 a	75.32 a
LSD	(P=0.05)	261.3	0.134	0.524	0.658	2.035

**DM excludes grain.*

What does this mean?

It is evident that abundant soil N at sowing and adequate plant available water from sowing to tillering provided a growing environment conducive to rapid dry matter accumulation and leaf area development for wheat after medic and vetch and to a lesser extent, wheat after canola. However, on soils with a limited capacity to store water such development exposed these crops prematurely to water stress at anthesis and during grain fill.

In direct comparison the slower rate of development for the continuous cereals reduced the rate of transpiration, thus not depleting the limited amount of plant available water as rapidly. The difference in grain yield between wheat after barley compared to continuous wheat is possibly due to early season conservation of water since the greater residue cover of barley trash is likely to reduce soil evaporation.

The grain yield of wheat after medic was less than the continuous cereal rotations although more than wheat after vetch. These results imply that the poor yield performance of wheat after medic pasture is due to excessive amounts of soil mineral N establishing a yield potential that cannot be achieved in low rainfall environments. The limited soil water holding capacity and unreliable rainfall during the growing season predisposes these crops to post anthesis drought. An improved understanding of N dynamics in these environments will assist in developing strategies to manage the inputs of N from legume residues.

Acknowledgements

I would like to acknowledge the trial co-operators Matt, Mignon and Peter Dunn, Penny Day, Annie McNeill and Cam Grant who have assisted me throughout the previous season.

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Key to symbols

Green manuring vetch or oats - an option for increasing grain protein?

***Mark Bennie*[1], *Penny Day*[2] *and Annie McNeill*[2]**

[1]*Minnipa Agricultural Centre* [2]*University of Adelaide*

Location
Minnipa
Minnipa Agricultural Centre

Rainfall
Av. Annual total: 326 mm
Av. Growing season: 241 mm
Actual annual total 2002: 278 mm
Actual growing season 2002: 219 mm

Yield
Potential: 2.18 t/ha
Actual: up to 1.6 t/ha

Paddock History
2001: Oats or Vetch
2000: Wheat, BT Schomburg

Soil
Sandy loam, pH 8.9

Key Messages Box

- **Green manuring vetch raises grain yield and protein.**
- **N input from vetch is greater than from oats.**
- **Spray fallow gives a similar N benefit to discing.**
- **No moisture storage benefit in 0-60cm depth from green-manuring at Minnipa.**

Why do the trial?

Current low-input continuous cropping practices on Upper Eyre Peninsula are gradually depleting soil N reserves. On Minnipa Agricultural Centre for example, some paddocks are starting to produce lower grain yield and quality. Incorporating a green manure vetch in the system every four to six years can potentially reverse this run down of nitrogen. Vetch also provides flexible management options including grazing, hay or seed, is a good break for common cereal diseases and can allow for reduced herbicide use if resistance is becoming an issue. The trial was designed to address the following questions:

- Does green manuring increase grain yield and protein?
- What's the difference in nitrogen input between vetch and oats?
- How important are the green tops in green manuring?
- Is there any sub-soil moisture storage after green-manuring?
- Is vetch or oats the better green manuring crop?
- Are responses better when green manured crops are disced or sprayed out?

How was it done?

Two green-manure treatments were applied in a split paddock at Minnipa Agricultural Centre of vetch (Languedoc) and oats (Wallaroo) following a low protein wheat crop in 2000. In September 2001, the oats and vetch were either turned in using a disc plough or sprayed off. It was necessary to slash the oats before turning in due to the heavy dry matter load.

The four treatments were: vetch mechanically incorporated (VM), vetch spray fallow (VS), oats mechanically incorporated (OM) and oats spray fallow (OS), and four plots of each. To gain an idea of the potential nitrogen inputs the dry matter and nitrogen content of the vetch and oats was assessed before green-manuring, and the soil was tested for moisture and available nitrogen to 60cm. Weeds were chemically controlled over summer. Wheat (Yitpi) was sown at 60 kg/ha on the 5th of June 2002 with 60 kg/ha of DAP. The plots were monitored over the season for crop dry matter and nitrogen content, soil moisture, available N and the amount of N in the microbial pool. Plots were harvested in November and final measurements made of grain yield and protein, stubble dry matter and nitrogen content.

What happened?

The input of dry matter from oats was 5.12 t/ha but this contained less nitrogen (65 kg N/ha) compared to the 2.6 t/ha dry matter for vetch (82 kg N/ha). The higher N input from the vetch was reflected in the much larger amounts of available N present in the soil to a depth of 60cm (Table 1) one month after the green manuring took place. There were no differences in amounts of N tied up in microbes in the top 20 cm of soil in November (Figure 1) and amounts were relatively low compared to those recorded for the 2002 season. Unfortunately 32-75% of the available N had disappeared by the pre-sowing sampling in June 2002 (Table 1). Some of the available N in the top soil depth may have been incorporated into microbes since these amounts had substantially increased (Figure 1), but the rest is likely to have leached beyond the rooting zone following any large rainfall events late in 2001.

Nevertheless, just prior to sowing there was still more available N under the green-manured vetch than the oats and the soil disturbance associated with mechanical incorporation appeared to have stimulated production of available N under both oats and vetch (Table 1).

Table 1: Available soil N (kg N/ha) and volumetric soil moisture (SM%) in 2001 about one month after green manuring oats or vetch by either using spray fallow (VS, OS) or mechanical incorporation (VM, OM); and just prior to sowing wheat in 2002.

Date	Treatment	VM		VS		OM		OS	
	Soil depth (cm)	Soil N	SM%	Soil N	SM%	Soil N	SM%	Soil N	SM%
Nov 2001	0-20	25	13	26	10	10	10	6	9
	20-40	17	19	39	15.5	6	13	6	11
	40-60	37	18	41	15	10	15	8	13.5
	TOTAL	**79**		**106**		**26**		**20**	
June 2002	0-20	26	7	18	7	9	8	4	8
	20-40	14	7	11	7	2	8	0.5	7
	40-60	14	10	11	11	2	11	0.5	11
	TOTAL	**54**		**40**		**13**		**5**	

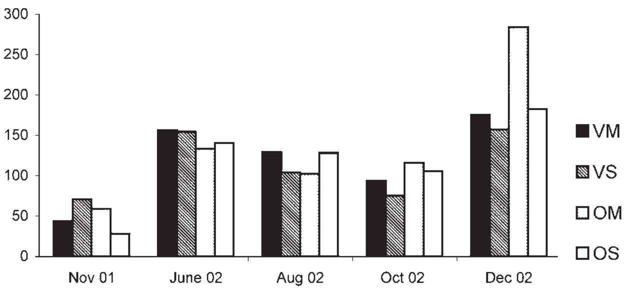

Figure1: Nitrogen tied up as microbes (kgN/ha) one month after green manuring in 2001 and at intervals during 2002.

There was greater soil moisture under the vetch than the oats shortly after green-manuring (Table 1), related to the lower dry matter production of the vetch. The moisture advantage did not appear to be long term as by the start of the next season the stored moisture in the top 60cm of soil depth had been depleted in all the treatments (Table 1) and volumetric soil moisture was similar at all depths (7-11%).

Table 2: Shoot dry matter and grain yield, nitrogen content and grain protein for wheat in 2002 following oats or vetch green-manured using spray fallow or mechanical incorporation.

Date	Treatment	VM	VS	OM	OS
15 August	DM (kg/ha)	0.42	0.33	0.38	0.28
	N (kg N/ha)	19	15	12	9
5 October	DM (kg/ha)	3.8	3.7	3.1	2.5
	N (kg N/ha)	57	61	38	30
17 November	Grain yield (t/ha)	1.6	1.5	1.2	1.1
	Protein (%)	13.5	14	10	10
	Grain N (kg N/ha)	38	37	24	20
	Stubble DM (t/ha)	2.8	3.2	2.1	2.1
	Stubble N (kg N/ha)	11	16	7	6

The higher amounts of available N under green-manured vetch resulted in higher shoot dry matter and N contents for the wheat at all sampling stages compared to wheat after green-manured oats (Table 2), although the method of manuring had no effect. There was also no effect of the manuring method on microbial N tie up during the 2002 season (Figure 1) but there are clearly quite large amounts of N cycling through this system. Higher grain yield and protein resulted after green-manured vetch than green-manured oats (Table 2), and the amount of N returned in the stubble was also greater.

What does this mean?

These results show that wheat grown after green-manured vetch has improved grain yield and protein over wheat grown after green-manured oats. Although mechanical incorporation rapidly stimulated production of available N, as reported by others (Mayfield and Amato, GRDC Final Report 1996), the method of green-manuring in this instance did not affect the outcome. Clearly it is better to avoid discing in situations where erosion risk is high, and this trial suggests that spray fallow can be as effective in increasing soil available nitrogen for protein. The results also indicate there may be a risk of leaching losses whilst using green-manuring to increase nitrogen inputs due to the lack of synchrony between production of plant available N from the residues and plant demand. The higher N in wheat stubble after vetch represents one way of 'trapping' more of the N benefit from green manuring for the longer term.

Acknowledgements

The authors would like to thank all the staff at Minnipa that helped with planning, maintaining and sampling this trial, and Damien Adcock for assistance with sampling.

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GRDC Grains Research & Development Corporation

Far West Farming Systems Competition

Samantha Doudle[1], Alison Frischke[1], Dr Tony Rathjen[2] and Peter Polkinghorne[3]

[1]SARDI, Minnipa Agricultural Centre, [2]University of Adelaide, [3]Penong

Location
Closest town: Penong
Cooperator: Polkinghornes
Group: Charra Ag Bureau

Rainfall
Av. Annual total: 325 mm
Av. Growing season: 240 mm
2002 annual total: 161 mm
2002 growing season: 137 mm

Yield
Potential: 1.2 t/ha
Actual: 0.67 t/ha

Paddock History
2001: pasture
2000: pasture
1999: pasture

Soil
grey calcareous loam with magnesia patches

Diseases
High prats

Plot size
40 ha each

Other factors
Poor growing season rainfall

Key Messages Box

- **Charra Ag Bureau won the first year of their own farming systems competition!**
- **Minnipa Researchers don't come last in a farming systems competition for once!**
- **High input systems come unstuck in the far west in 2002.**

Why do the trial?

For years, researchers and agronomists have been venturing out to the far west coast and sharing with farmers the benefits of their collective wisdom. For years, farmers on the far west coast have been mumbling, "that won't work, it's different out here". Finally, at the Charra Ag Bureau Sticky Beak Day in 2001, the farmers decided it was time to challenge the "experts" to come out to the far west and put their money where their mouths were. 2002 was the first year of the Far West Farming Systems Competition - a chance for researchers to demonstrate their new techniques on a broadscale and a chance for farmers to try something new with minimal risk (except of course possible damage to one's reputation!). The inspiration for all teams in this competition is the rule that the losers must take the two other teams on a fishing trip!

How was it done?

An area adjacent to the Eyre Highway on the property of Peter, Judy, Ben & John Polkinghorne, 15km east of Penong was chosen as the battle ground. In January 2002, the entire site was EM (electromagnetically) mapped to give the teams an indication as to who had the worst of the ground as far as transient salinity went. Each 100 acre area was also disease tested to assess the background soil disease levels for each team. A "fair" draw was duly conducted, once again leaving the Researcher's team with the worst patch of ground in the competition (refer to the MAC Farming Systems Competition - same deal mate!). Not only did the Researchers have higher soil salinity levels and quite likely higher soil disease levels, but they also acquired a larger white snail population (some as big as watermelons) and a much friendlier and more populous mouse civilisation - this was according to the Researchers anyway!

The competition consists of three teams:

"**The Charra Ag Bureau**" - a dynamic group of farmers on the far west coast of Eyre Peninsula, most of whom are already experts in risk management. The Charra mob have a very simple aim for their patch - to beat everybody else! They have a feel for what will and won't work long term in their area and their risk management strategies are sometimes viewed as conservative by folks who haven't farmed the country themselves.

"**The Eccentric Scientist**" - led by one of South Australia's great wheat breeders, Dr Tony Rathjen. This team's policy is to reduce Pratylenchus numbers using increased nutrition and reduce subsoil salinity levels. Tony has been a great supporter of the Charra Bureau and on most Sticky Beak Days can be found in the middle of a group of farmers "stirring the pot".

"**The Researchers**" - fondly referred to as the "Birds from Minnipa", this team consisted of Minnipa Ag Centre Researchers Ali Frischke and Sam Doudle. The "Birds" were aiming to set up a system that retained as much trash as possible to provide shade and wind protection for the emerging crops and encourage the salt to remain lower in the soil profile. In 2002 they aimed to demonstrate fluid fertiliser technology, banking on the rapid early growth from fluid fertilisers to give them a head start in the ground cover stakes. However the brew they used turned to jelly when mixed at seeding time, causing much consternation and could we say "oath making" for the Polkinghorne clan. The "Birds" would like to publicly announce that the "brew" was checked beforehand by an "expert", who shall remain anonymous for the purpose of this exercise!

What happened?

At the annual Charra Sticky Beak Day, it really looked as though the "Research Birds" were going to be the fishing trip hosts. Out of 36 votes cast in the crop estimates competition, only 3 people thought the "Research Birds" would not come last - how perceptive of Trevor Oats, Allen Stott and Mario Nicholls to realise that they wouldn't.

Rankings based on yields from the header

1st Place: Farmers

2nd Place: District Practice

3rd Place: Research Birds

4th Place (and fishing trip host!): Eccentric Scientist

We kept the estimates and despite being laundered a few times, we were able to read who estimated what. The actual winners of the crop estimate competition are (district practice was not part of the crop estimates competition):

Farmer's Paddock (actual yield 0.71 t/ha): Messy (0.72 t/ha), Shaun Nicholls (0.70 t/ha), Mildy Chandler (0.72 t/ha)

Eccentric Scientist's Paddock (actual yield 0.56 t/ha): Allen Stott (0.55 t/ha)

Researcher's Paddock (actual yield 0.61 t/ha): Mark Hoffrichter (0.61 t/ha), Owen Chandler (0.61 t/ha), Butch Dunn (0.61 t/ha)

What does this mean?

Even the farmers only managed to produce a crop which reached 60% of the yield potential. Since the extra fertiliser inputs by the eccentric scientist team actually reduced yield, it seems unlikely that the low farmer yields were due to lack of nutrition. The hostile nature of subsoils in the district seem a prime candidate to hold yields back from potential but also possible is that the pattern of growing season rain last year was not suited to good performance of wheat. Or maybe there is something else??

High input systems on the far west coast- are they a risk or a reward? High input systems are a very risky scenario on the far west coast, unless they can return consistently higher yields across a variety of seasons. All teams used higher inputs, and the team to suffer the most in the very dry conditions of 2002 was the one with the highest inputs - the Eccentric Scientist team. Polkinghorne's noticed good early growth on this patch, however as conditions became drier this extra growth gradually emptied the soil profile of moisture quicker than the other teams who had less initial growth.

What went wrong with the "Birds" fluid mix? Well, despite consulting the resident expert and then using a brew that had proven successful in other experiments and then making up a sample to double check the mixing compatibility, and then re-consulting the expert to make sure it really would be OK, we still managed to provide a headache at seeding time for the Polkinghorne's. During desperate phone calls at seeding with the same expert, it turns out that the mix was

Root Disease Testing Service Results for the whole paddock

Rhizoctonia: medium (69), Pratylenchus neglectus: high (44) - no other root diseases present.

		Farmers	Eccentric Scientist	Researchers	District Practice
Pre-sowing	Working	Worked up	Worked up	Worked up	Worked up
	Fertiliser	Pre Drill 18:20 @ 25 kg/ha + 4% Zn	Pre-drill urea @ 40 kg/ha (18 kg N/ha)		
Sowing	Variety	Yitpi @ 57 kg / ha	Yitpi @ 75 kg/ha	Yitpi @ 60 kg/ha	Yitpi @ 57 kg / ha
	Fertiliser	18:20 + 4% Zn @ 50 kg/ha	18:20 + 4% Zn @ 75 kg/ha	Tech Grade MAP, Urea, Ammonium Nitrate, Zinc Sulphate. Aiming for 8 kg P/ha, 8 kg N/ha, 1 kg Zn/ha. Due to mixing problems, probably only ½ rate went on	18:20 + 4% Zn @ 50 kg/ha
August			Copper, zinc & manganese application		
July	Chemical	400 mL/ha MCPA	400 mL/ha MCPA	400 mL/ha MCPA	400 mL/ha MCPA
Harvest		yield: 0.71 t/ha, protein: 14%, screenings: 0.8%, test weight: 81.4 g/hL, moisture: 11%	yield: 0.56 t/ha, protein: 14.3%, screenings: 1%, test weight: 80.4 g/hL, moisture: 11.3%	yield: 0.61 t/ha, protein: 14.2%, screenings: 1%, test weight: 81.2 g/hL, moisture: 11.5%	Yield: 0.67 t/ha
Gross Margin		$ 146/ha	$ 81/ha	$ 100/ha (GM worked on half fertiliser rate, as only approx ½went on)	$159/ha

Comments from the Competition Manager - Peter Polkinghorne

Farmers - other than pre-drilling DAP + 4% Zn @ 25 kg/ha, our management was the same as all the rest of our fresh ground and we beat you on yield.

Researchers - complete box up with fluids - got on about 1/2 of what you sent up. Had the worst of the magnesia patches. I was surprised at the final tonnage. Your gross margin would be good.

Eccentric Scientist - killed it with kindness - too much of everything. Gross margin would be shit house!

compatible, however the water rate on Polkinghorne's seeder was not high enough to dissolve the amount of nutrients planned. We promise this will not happen again!!

How are fluids working on the far west coast? The Polkinghorne family have now been using fluid fertilisers on their property for two years in one exceptionally wet and one exceptionally dry year. In 2001, the wet year, they noticed differences in crop growth early, but this did not carry into any yield benefit. In 2002, the dry year, they didn't notice any early crop growth or yield differences. They are disappointed with the results they have had with fluid fertilisers and are looking to find out why they haven't seen the same yield gains as those achieved in the fluid fertiliser research program.

Plans for this year

(NB: the competition will be shifting to a new site on softer soil)

Farmers - The farmers haven't had a get together yet, but it is likely that they will use fluids this year, although they are not sure what type. They are sure that it will definitely be purchased in liquid form, none of this mixing up stuff from bags!

Eccentric Scientist - at the time of writing this article the Rathjen family are going through a tough time. We all wish them well for the future and we'd like to publicly thank Tony for his support for farmers and research on Eyre Peninsula, particularly the Far West Coast. Pity he doesn't like fishing, otherwise we probably would have offered to organise the fishing expedition for him this year!

Researchers - firstly we need to recruit a new "bird" for the year as Ali is off on maternity leave. This could be difficult and the thought of having Fish, Nigel or Bob in a wig and skirt is something we could all have nightmares over. However, we will stick with the same aims of getting quick ground coverage and maintaining as much trash as possible. Seeing as we are moving to a new site this year, we'll just sit on the fence until we've seen the disease and soil tests. We also plan to rig the draw for ends, so that for just once we get the best bit of dirt in the competition!

Acknowledgments

- The Polkinghorne family for hosting and managing the competition.
- Natural Heritage Trust, through the Eyre Peninsula Community Landcare Project for competition support.

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Natural Heritage Trust
Helping Communities Helping Australia

Location
Closest town: Minnipa
Cooperator: Minnipa Agricultural Centre

Rainfall
Av. Annual total: 326 mm
Av. Growing season: 241 mm
2002 annual total: 278 mm
2002 growing season: 219 mm

Yield
Potential: 2.18 t/ha

Soil
Sandy clay loam, pH 8.5

Type of Research
Broad scale competition

MAC Farming Systems Competition

Proudly sponsored by AWB Ltd

AWB

Samantha Doudle and Mark Bennie

SARDI, Minnipa Agricultural Centre

Key Messages Box

- **Farmer Team hit the lead in the third year of the competition.**
- **Consultant Team lose the lead to their clients!**
- **Research Team...hmmm? ...won the Mid West Footy Grand Final for the first time in decades!**

Why do the trial?

This is the third year of a broad scale farming systems competition on Minnipa Agricultural Centre. The success of our farming enterprises is determined by how well we utilise the soil, environmental and financial resources we have. This competition aims to demonstrate the consequences of four different approaches to managing the same bit of land. This “same bit of land” is actually four separate and adjacent paddocks of three hectares on Minnipa Agricultural Centre. You can follow the progress of the competition every year at the Minnipa Agricultural Centre Field Day and through this publication.

How was it done?

The competition is divided into three teams - The Farmers (Mid West Farmers Group), The Advisers (both private and PIRSA Rural Solutions SA) and The Researchers (MAC staff). Each team has been allocated one paddock have the challenge of farming it to become the most profitable and sustainable team in both the short and long term. A fourth paddock contains ‘district practice’, a farming system decided by consensus of the three teams. Each team is responsible for planning the complete management of their paddock, with the only constraint being that all operations must be possible using MAC equipment (unless the team can make other arrangements). All teams have access to the full range of marketing options provided by AWB to convert their products into cash.

What happened?

Team 1: The Farmers (The Not Too <u>Cocky</u> Cockies)

Team motto: - to farm profitably today, while giving our kids the chance to do the same tomorrow.

What did we learn last year?

We were aiming for a relatively low risk and profitable option and wheat on wheat gave us that with 1.48 t/ha and a GM of $315/ha, which was OK given the season. This result was due to good weed control, low seeding rate, and a well planned and strong paddock history. Our careful use of fertilisers, chemicals, seeding systems, wheat varieties and sheep in our system have proven themselves. A small amount of barley grass is showing up and will be dealt with this year. Despite controlled traffic being difficult in our small paddocks we will persist with it - hopefully. In hind-sight, marketing our grain through the AWB pool proved to be a reasonable option.

2003 Plans:

Our team has observed few weeds, diseases or nutritional problems (our wheat sample indicated this) giving us the confidence to go in with another wheat (probably Krichauff again) at 40 kg/ha. To ensure continuing good weed control we hope for an early break to the season, a good barley grass germination and knockdown before seeding. We aim to sow as early as possible after the germination, with seed (Jockey included) and fertiliser much the same as last year and a Diuron/Trifluralin brew. AWB marketing options will be reviewed during the season.

We continue to uphold our teams title and motto and let the gross margins do the talking!

Team 2: The Advisers (De$perately $eeking $olutions)

Team motto: If we get trounced, please blame Ed Hunt

What did we learn last year?

A pretty low risk option of wheat on wheat was used and the result of 1.25 t/ha was reasonable given the season. We were a bit lucky that the test weight got through (at 74.4), and this may be due to the fact that 1/2 of our paddock was headlands (as anyone at the Field Days saw). Only using 60 kg/ha of DAP proved adequate for the season (no extra N), as it has a reasonable medic history.

2003 Plans

We will wait and see what the researchers have planned - and do exactly the opposite given that all their decisions have gone belly up (so far). Seriously, it is likely to be another cereal. The main reason is that we will need to observe plant back periods for the Logran used in 2001. The dry 2002 means that the rainfall requirement (of 700mm) before being able to sow legumes or canola is unlikely to be satisfied (unless we get good summer/early autumn rain). So we will hope for that elusive early break to allow a barley grass germination and knockdown prior to seeding. Wheat is an option as is barley (if we can get onto some of Andy Barr's advanced breeding lines of super high yielding, boron tolerant, totally disease and stress resistant variety that always makes malt grade!).

Team 3: The Researchers (The Starship Enterprise)

Team motto: Boldly going where no man has gone before.

What did we learn last year?

The competition continues to be a tough learning process for the ivory tower league, and perhaps the hardest lesson learnt so far is that how you do something may be just as important as what you actually do. Poorly timed operations have hurt our paddock's productivity and profitability but we will rise from the ashes!! For example, we did detect a high population of wild oats in the wheat of 2001 but too late to make herbicide control an option - hence we converted a good wheat crop into low value hay. Similarly in 2002, we noticed the barley running out of N but by the time we reacted the N spray went out pretty late and almost certainly did no good (perhaps a blessing in disguise although our proteins were low enough to suggest that some more early N may have been beneficial).

2003 Plans

Our plan (for want of a more accurate term for a committee's ponderings) for this year is to sow conventional canola on wide rows. Why?

- Because we think that wild oats are still our number one threat to future profitability and we are determined to deplete the population - canola gives us another big shot at them,
- Because we have contracted some of the crop at $430/tonne and we think that reduces the risk with canola substantially and to acceptable levels,
- Because a vigorous break crop of canola should set us up well for several cropping years to come,
- Because with wide rows (to help the crop finish off) and early seeding, we believe that at least reasonable production from canola is likely, and
- Because after four years of cereals and a chemical fallow, we expect broad-leaved weeds to be in low numbers and there are no residual herbicide concerns.

We will continue with our theme of higher inputs because we still believe that there is enough evidence from around the traps that although we have not harvested the rewards yet it will pay for itself (and then some) in a good year. We also want the extra biomass production to foster more bugs in the soil, to better protect the soil from wind erosion, to improve establishment of break crops such as peas.....

So, watch out all you cocky $olutions!! We may be starting a long way back but that will just make the victory that much sweeter. To those of you who think the canola option is just another scheme for the researchers to avoid an income tax problem, we say, "We are public servants and we can't help but live life on the edge!! Seed canola or bust (or is that seed canola and bust)?!?! Let the season begin!"

Acknowledgments

- AWB Ltd for sponsorship of this competition.
- MAC farm staff, Brett & Ted McEvoy for sowing, managing and reaping the paddocks.
- Mark Bennie for coordinating the competition and keeping paddock records.

Rotations

MAC Farming Systems Competition - Paddock Management Details: 1999 - 2002

	Date	Farmers	Consultants	Researchers	District Practice
1999		Parafield Peas @ 0.36 t/ha	BT Schomburg Wheat @ 1.33 t/ha	Wallaroo Oats @ 0.67 t/ha	Chemical Fallow
2000		Chemical Fallow, Summer Crop, Legend Sorghum @ yield 50 kg/ha. GM = -$57/ha	Chemical Fallow/summer weed spray, GM = - $21/ha	Chemical Fallow, GM = -$13/ha	Chemical Fallow, GM = -$11/ha
2001		Yitpi Wheat: Yield: 2.75 t/ha, Prot: 13.6%, Scrn: 5.6% & TW: 75.4g/hL. GM = $600/ha	Yitpi Wheat: Yield: 2.77 t/ha, Prot: 11.6%, Scrn- 4.6% & TW- 75.4 g/hL. GM = $572/ha	Broadcast Frame Wheat: slashed and baled (wild oat problem). Yield: 22 round bales. GM = $207/ha	Yitpi Wheat: Yield: 2.79 t/ha, Prot: 12.3%, Scrn: 4.9% & TW: 75.6 g/hL. GM = $575/ha
Running Gross Margin, after 2001		$543/ha☺	$550/ha☺	$195/ha☹	$564/ha☺
2002 Management	29/5/02	Credit @ 500 mL/ha, Triflur 480 @ 800 mL/ha	Credit @ 500 mL/ha, Triflur 480 @ 800 mL/ha	Credit @ 500 mL/ha Triflur 480 @ 800 mL/ha Avadex BW @ 2 L/ha	Pasture
	29/5/02	Krichauff @ 40 kg/ha,18:20 @ 30 kg/ha, Urea @ 30 kg/ha	Krichauff @ 70 kg/ha,18:20 @ 60 kg/ha	Barque @ 50 kg/ha, 18:20 @ 60 kg/ha	Grazed
	6/6/02	Nuquat 200 @ 400 mL/ha	Nuquat 200 @ 400 mL/ha		
	17/7/02		Zincsol @ 2 L/ha		
	23/7/02			Hoegrass @ 1 L/ha, MCPA LVE @ 700 mL/ha, Zincsol @ 2 L/ha, Chemwet @ 250 mL/ha	
	25/7/02	Ally @ 5 g/ha, MCPA LVE @ 250 mL/ha, Zinc Sulphate @ 1.5 kg/ha			
	15/8/02		Amicide 500 @ 500 mL/ha	Urea @ 35 kg/ha (Foliar)	
		Grazing – 2 weeks sheep agistment (25c/head/week) @ 2.5 DSE/ha	No grazing	Grazing – 3 weeks sheep agistment (25c/head/week) @ 2.5 DSE/ha	Grazing – 4 weeks sheep agistment (25c/head/week) @ 2.5 DSE/ha
		Krichauff Wheat, Yield: 1.48 t/ha, Prot: 12.4%, Scrn: 1%, TW: 77.2, % Pot Yield: 68%, GM = $316	Krichauff Wheat, Yield: 1.25 t/ha, Prot: 11.8%, Scrn: 3.3%, TW: 74.4, % Pot Yield: 58%, GM = $231	Barque Barley, Yield: 1.36 t/ha, Prot: 11.4%, Scrn:34.8%, TW: 72.6, % Pot Yield: 53%, GM = $195	GM = -$4
Running Gross Margin, after 2002		$859/ha☺	$781/ha☺	$390/ha☹	$560/ha☺


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Section 5

Section editor: Samantha Doudle

Eyre Peninsula Farming Systems

Project Coordinator,

Minnipa Agricultural Centre

Disease

Unlike 2001, with a high incidence of diseases related to moist conditions, the dry conditions in 2002 increased the impact of diseases that thrive on moisture stressed plants. Crown rot was particularly rife in susceptible varieties like Frame and could have major implications on the development of durum production on EP.

Rhizoctonia was also widespread on upper EP in 2002.

Some highlights of this section include:

- the first hard evidence that fluid fertilisers do have a positive impact on plants suffering root diseases.
- the developing ability to identify and manage high disease areas of the paddock differently to those with low or no disease by using precision agriculture.

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UNITED GROWER HOLDINGS

Location
Penong
P Polkinghorne
2002 April-Oct rainfall: 138 mm

Soil
sandy loam
Colwell P: 53 mg/kg
Calcium Carbonate: 8%

Plot size
1.5 x 5 m

Streaky Bay
P & N Wheaton
2002 April-Oct rainfall: 232 mm

Soil
sandy loam
Colwell P: 37 mg/kg
Calcium Carbonate: 36%

Plot size
1.5 x 5m

Eyre Peninsula Fumigation Trials 2002

David Roget CSIRO Land and Water, Adelaide and Alison Frischke
SARDI, Minnipa Agricultural Centre

Key Messages

- **Fumigation treatments increased the early plant growth and yields at both Streaky Bay and Penong indicating the presence of a biological constraint to production.**
- **At Streaky Bay the biological constraint was identified as Rhizoctonia root rot while the constraint at Penong was not identified.**
- **At both sites, yield responses to improved nutrition were limited unless the biological constraint was removed.**
- **Estimates of potential yield indicated that at both sites, but particularly at Penong, significant constraints to production were still present even after improved nutrition and fumigation.**

Why do the trial?

Fluid fertiliser responses on the calcareous grey soils of Eyre Peninsula have been demonstrated consistently. The fumigation trial was established to determine if:

1. There were any biological limitations to wheat production that may be limiting the benefits of improved nutrition (fluids).
2. There are other factors still limiting crops from reaching yield potential.

In many regions crop production is still well below the potential that can be achieved for the rainfall that is available. The limitations to crop production may be due to a range of physical, chemical or biological constraints. Soil fumigation is a useful research tool to identify if biological factors are significantly affecting crop growth. The fumigation process removes most of the soil organisms, both the pathogens and the beneficial ones. The fumigated soil begins to be re-colonised quite quickly from adjacent unfumigated soil but not before the fumigation impact on the plant has occurred. Soil fumigation can also release nutrients, particularly N, and this needs to be considered when evaluating any fumigation responses. This work is part of the GRDC National Fumigation Project to assess the extent of soil biological constraints to production and to help identify areas that require research in the future.

How was it done?

Trial Details: Trials were established at Penong and at Streaky Bay in 2002. Treatments and the nutrients supplied in each are given in the table below.

Treatment	Nutrients applied (kg/ha)	
	Penong	Streaky Bay
1. Nil - fumigation	-	-
2. Nil + fumigation		
3. Granular - fumigation	12 P, 11 N	14 P, 15 N
4. Granular + fumigation		
5. Fluid - fumigation	18 P, 14 N, 1 Zn, 1 Cu, 1 Mn	20 P, 15 N, 1 Zn, 1 Cu, 1 Mn
6. Fluid + fumigation		

To fumigate plots, plots were watered and covered with plastic, then had methyl bromide gas pumped under the plastic, which was removed after 3 days. Plots were then left a minimum of 2 weeks before sowing.

Granular fertiliser was applied as di-ammonium phosphate and urea, while fluid treatments were applied as phosphoric acid at Penong, and ammonium polyphosphate at Streaky Bay, with urea ammonium nitrate and zinc, copper and manganese chelates at both sites. Both sites were direct-drilled with Krichauff wheat; Streaky Bay on 4th June and Penong on 18th June.

The fertiliser treatments were not intended to compare granular and fluid fertilisers, but to compare the district practice application of granular fertiliser, with increased and more available nutrients (i.e. improved nutrition), which were supplied by the fluid fertiliser.

Measurements: Dry matter production at early tillering, rhizoctonia patch estimates (tillering), root disease scores, mycorrhiza analysis, grain yield.

What Happened?

Streaky Bay. Early dry matter production was dramatically increased following fumigation but only in the fluid treatment (Fig. 1a) and corresponded to a decrease in the area of rhizoctonia patches (Fig. 1b). The area of rhizoctonia patches was lower for all fertiliser treatments following fumigation, however it was the combination of reduced pathogen levels from the fumigation treatment and the improved nutrition from the fluid treatment that effectively controlled rhizoctonia.

In the non-fumigated treatments, yields were highest with fluids followed by granular fertiliser and nil fertiliser but the effects were not large (Fig. 1c). Fumigation increased yields in the fluid treatments by 10% but this was still 0.6 t/ha below the calculated potential yield indicating there is still a significant factor affecting crop performance. Fumigation actually reduced yields following either the granules or nil fertiliser treatments. The reduction in yield following fumigation is an unusual result and may reflect the loss of beneficial soil microbes. Mycorrhizal fungi can be beneficial in obtaining nutrients such as P for plants when the availability of P is low. Wheat is generally not regarded as a plant that benefits from mycorrhizal association but this may not be the case for the grey calcareous soils where fixation of P can rapidly occur.

Penong. Early dry matter production was highest with the fluid treatments, less with the granular and lowest following nil fertiliser (Fig. 2a). Following fumigation, dry matter production increased with both the fluid and granular treatments but decreased where no fertiliser was added.

There was no significant effect of fertiliser treatment on wheat yield for the non-fumigated treatments (average 0.40 t/ha) (Fig. 2b). Fumigation increased yields for the fluid treatment (0.53 t/ha) but decreased yields for the granular (0.32 t/ha) and nil treatments (0.26 t/ha). Yield potential for this site was calculated at 1.6 t/ha, which indicates that there are still major non-biological limitations to crop production. Yield potential calculations were based on information from the Mallee Sustainable Farming Project, which indicates that in seasons with low growing season rainfall (as at Penong in 2002) an evaporation loss of around 60 mm is more applicable than the established figure of 110 mm.

Results for root infection and mycorrhiza levels are still to be analysed.

What does this mean?

Improved nutrition has the potential to significantly increase production on the grey calcareous soils however the full yield benefits are unlikely to be realised were there are biological constraints (root disease) present. Even with improved nutrition (fluid treatment) and disease control (fumigation), yields were still significantly below the potential - particularly at Penong. This indicates that there are still factors impacting on production that need to be addressed.

The decline in yields following fumigation for the granular and nil fertiliser treatments suggests the possibility that mycorrhizal fungi may have a significant impact on nutrient availability at these sites. However, the response to fluid fertilisers indicates that any potential benefit from mycorrhizal fungi, while useful, is not sufficient for optimum wheat production.

Acknowledgements

The work was funded by the GRDC Soil Biology Initiative and would not have been possible without the valuable assistance of Wade Sheppard (Minnipa Agricultural Centre) and John Coppi (CSIRO Land and Water).

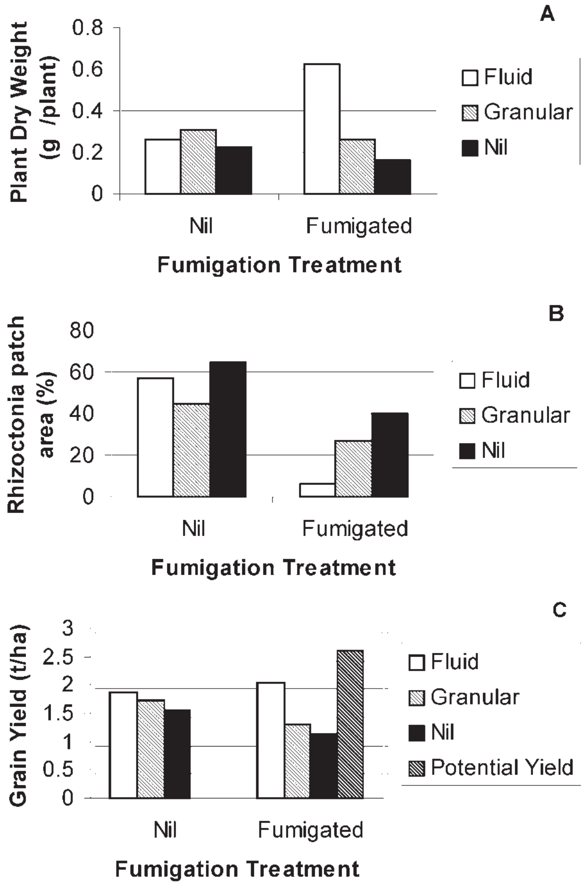

Figure 1: Dry Matter Production (A), Rhizoctonia Patch (B) and Grain Yield (C) for Streaky Bay.

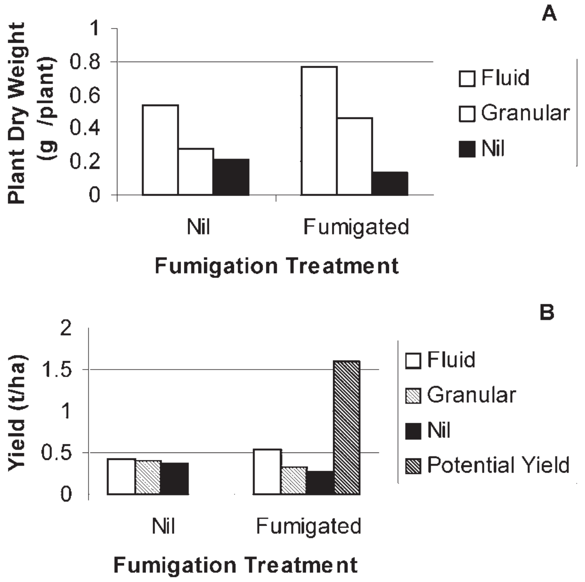

Figure 2: Dry Matter Production (A) and Grain Yield (B) for Penong.

GRDC Grains Research & Development Corporation

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CSIRO

Disease

Location
P & N Wheaton
Streaky Bay
April-Oct Rainfall
232mm

Potential Yield
2.4 t/ha

Soil
Grey highly calcareous sandy loam
Approx. 60% calcium carbonate

Plot Size
1.5 x 13 m

Combating Disease with Fluid Fertilisers

Alison Frischke and Bob Holloway,
SARDI, Minnipa Agricultural Centre

Key Messages

- **The use of fluid fertilisers does not eliminate disease patches, but plants within the diseased patches are less affected.**
- **The combined effects of improved nutrient uptake and reduction in disease severity, results in overall grain yield improvements with applications of fluid fertiliser compared with granular fertiliser.**

Why do the trial?

Over the past 5 years of conducting fluid fertiliser experiments, it has been observed on many occasions that plants sown with fluid fertilisers are better able to cope with root disease than plants sown with granular fertilisers. The use of fluid fertilisers does not eliminate disease patches, but plants within the diseased patches clearly have had better colour and vigour. This trial was designed to measure this effect.

How was it done?

Plants were sampled from selected treatments in a fluid fertiliser experiment at Streaky Bay. The soil type is a grey highly calcareous sandy loam with a calcium carbonate level of 60%. Crops grown in this soil type are very susceptible to root disease attack and respond well to improved nutrition. The experiment was designed to measure the efficiency of suspension fertilisers (slurries made from fine granular fertilisers, using clay to keep the solids in suspension) compared with granular fertilisers and commercial clear fluid fertilisers. The nil treatment received no nutrients, while the DAP (18:20), Easy NP((Incitec slurry) and APP (14:21, clear fluid) treatments all received 14 kg P/ha, 14 kg N/ha and 2 kg Zn/ha.

What happened?

Visual differences in plant vigour and their ability to cope with disease were quite large between fertiliser treatments early in the season. By the time sampling was done at booting, visual differences were less pronounced but still evident.

Dry matter production of tops and root scores for rhizoctonia and Pratylenchus neglectus were recorded for samples of plants taken from poor and good performing areas in each plot. Rhizoctonia and Pratylenchus were scored together as the site had initial Predicta B DNA analysis disease risks in the high category for both diseases, and symptoms are not distinguishable from one another. (Root scores were on a 0-5 scale where 0 = nil damage, to 5 = damage to all roots.)

Fluid fertilisers decreased the disease score compared to granular fertiliser, and granular treatments were no better than nil fertiliser.

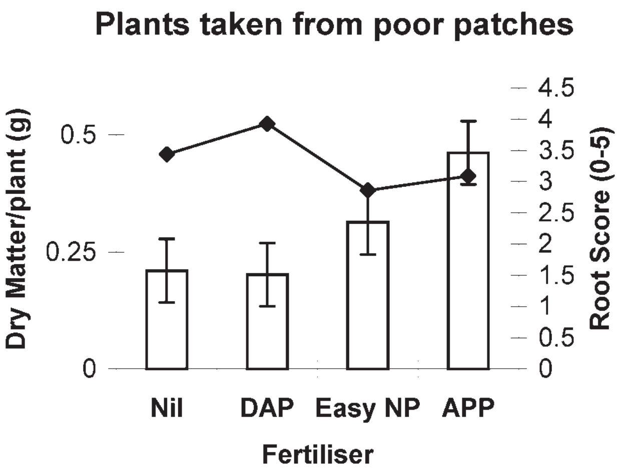

Figure 1: Dry matter production (bars) and root disease scores (line) of Krichauff wheat plants taken from poor areas of the plot.

Figure 1 illustrates that for plants taken from poor patches, there were similar levels of rhizoctonia/pratylenchus infection in all fertiliser treatments, and all were severe. This suggests that where root disease inoculum levels were high, the same level of root infection occurred irrespective of the fertiliser treatment. However, there were differences in dry matter production (shown by the bars), with APP producing 36% more dry matter than granular DAP. So despite no differences in disease severity, when plants were sown with fertilisers increasing in nutrient availability, they were better able to acquire nutrients and continue plant growth.

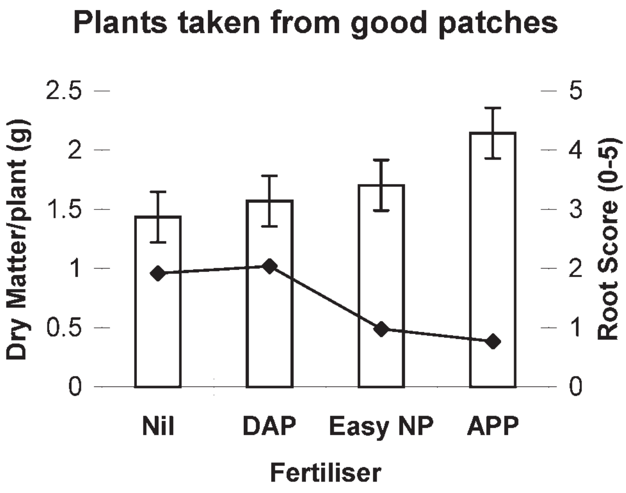

Figure 2: Dry matter production (bars) and root disease scores (line) of Krichauff wheat plants taken from good areas of the plot.

For plants sown with APP taken from good areas in each plot (Figure 2), root disease severity decreased and dry matter production increased. It has been shown that for plants grown in soils with a nutrient deficiency, root systems become more vigorous when supplied with adequate levels of the deficient nutrient. We can then speculate here, that when disease inoculum and hence root damage was lower, plants sown with fertilisers of greater nutrient availability had greater root vigour and were able to grow through the band of disease inoculum faster (principally the top 5cm). Roots were therefore less susceptible to disease attack as the growing tips (the point of infection) were in the infection zone for less time. Other possibilities are that nutrient adequate plants were more resistant, i.e. less initial infection, or that the fertiliser is toxic.

Following the above trends with increasing effectiveness of fertilisers was a reduction in the amount of plot area affected by disease, and an improvement in grain yield.

Table 1: Disease Patch and Grain Yield of Krichauff Wheat.

Treatment	% of Plot with Disease Patch	Grain Yield (t/ha)
Nil	75	1.13
DAP	63	1.28
Easy NP	33	1.51
APP	32	1.59
LSD ($p<0.05$)	ns	0.29

What does this mean?

When the nutrient supply to deficient plants is increased, plants are better able to cope with root disease. Fluid fertilisers are known to be more available on highly calcareous soils, and consequently phosphorus, nitrogen and zinc uptake is greater with fluid fertiliser application compared with granular fertilisers. The use of fluid fertilisers does not eliminate disease patches, but plants within the diseased patches are less affected. The combined effects of improved nutrient uptake and reduction in disease severity, results in overall grain yield improvements with applications of fluid fertiliser compared with granular fertiliser.

Acknowledgements

This work was funded by GRDC, and would not have been possible without the valuable assistance of Philip and Nigel Wheaton (Streaky Bay), Leigh Davis and Wade Shepperd (SARDI, Minnipa).

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Disease

Location
Minnipa Agricultural Centre
Red sandy loam.
Ave rainfall: 326 mm
GSR: 241 mm

Wharminda
Siliceous sand over clay
Ave rainfall: 272 mm
GSR: 141 mm

Diseases
High levels of Rhizoctonia at Wharminda

Plot size
26 m x 1.44 m

Other factors
Drought at Wharminda in 2002

Effect of Cropping Practices on Crown Rot

Jerry Dennis[1] and Alison Frischke[2],

SARDI[1] Plant Research Centre, Waite, [2] Minnipa Agricultural Centre

Why do the trials?

Crown rot of wheat has become a prominent disease on Eyre Peninsula because stubble retention and intensive cereal rotations have built up disease inoculum in paddocks. The disease is most severe in dry years such as 2002, but in some areas of eastern EP significant crop losses occur every year.

These trials investigated the effects of stubble burning or cultivation, and break crops on inoculum survival and disease development. They also looked at the effect of more resistant varieties and improved fertiliser application on disease development and inoculum survival.

How was it done?

Trials were established at Minnipa and Wharminda in 2000 (Table 1) in paddocks severely affected by crown rot in 1999. At Minnipa infected stubble was retained, cultivated, or burned before both variety and fertiliser treatments were applied. Treatments at Wharminda were sown into retained stubble.

Treatments at Minnipa and Wharminda in 2000

Minnipa

Main treatments

- Stubble raked and burned
- Stubble retained
- Stubble buried to 10cm by discing

Sub treatments

- Grass free medic pasture
- Tamaroi durum
- Frame wheat granular fertiliser.
- Frame wheat liquid fertiliser.
- Frame wheat liquid fertiliser and trace elements.

Wharminda

- Grass free pasture
- Schooner barley (susceptible to crown rot)
- Tamaroi durum (very susceptible)
- Wheat variety 2-49 (moderately resistant)
- Kukri wheat (moderately resistant)
- Frame wheat (susceptible)
- Frame wheat - trace elements with seed
- Frame wheat - trace elements below seed.

Plots were scored for crown rot development (infected plants and whiteheads) and grain yield in 2000 to determine the direct effects of these treatments in the following crop. Soil samples were taken from plots in March 2001 and March 2002 to determine the effects of treatments on soil inoculum. Both trials had break crops in 2001 (peas at Minnipa and grass free pasture at Wharminda).

In 2002 all plots at Minnipa and Wharminda were sown with Tamaroi durum at 70 kg/ha with 60 kg/ha DAP. This was to maximise crown rot development so the effects of rotations and plot treatments in 2000 on crown rot inoculum survival and subsequent disease development could be determined. Plots at both sites were assessed for infected plants and whiteheads (%) in October and harvested for grain yields in December.

What happened?

The main influences on crown rot development and inoculum survival were crop variety and rotation with little effect from stubble and fertiliser treatments. It should be noted, however, that stubble burning has been effective at other sites.

Crown rot infection (% infected plants) at Wharminda in 2000 was less in the more resistant wheat varieties, Kukri and 2-49, compared to Frame, and higher in the more susceptible Tamaroi durum (Table 2). The better adaption of Frame, resulted in less whiteheads and higher yields than Kukri despite more infection.

There was less disease development (whitehead %) and higher yields (Table 2 and 3) in the crop following Kukri and 2-49 than after Frame. This gives some indication of a carry over effect from more resistant varieties, although this was not substantiated in the soil inoculum and plant infection scores. Inoculum levels and subsequent disease development were high following barley and durum but not different to Frame.

The biggest effect on reducing soil inoculum levels and subsequent disease development at Minnipa was two consecutive years of break crops (Table 3). While inoculum levels and disease development were less for a wheat-peas rotation compared to durum-peas rotation, inoculum levels for both treatments were still high after a one year break.

A pasture-pasture rotation at Wharminda also showed a greater reduction in inoculum and disease development (infected plants and whiteheads) compared to cereal-pasture rotations (Table 3) but this was not reflected in the yields. It is likely that yields have been compromised by other factors (e.g. high levels of Rhizoctonia in the trial) since whitehead development is normally a good indicator of yield loss.

Table 2: Stubble management, fertiliser and variety effects on crown rot infection and yield of cereals

Trial	Treatment 2000[A]	2000			2002		
		Infected Plants (%)	Whiteheads (%)	Yield (t/ha)	Infected Plants (%)	Whiteheads (%)	Yield (t/ha)
Stubble treatments (Minnipa)	Retain	48	15	1.56	36	14	1.34
	Burn	37	11	1.58	38	13	1.41
	Cultivate	48	15	1.32	38	14	1.39
	lsd (P=0.05)	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*
Fertiliser (Wharminda)	Granular	11	5	2.44	64	20	0.40
	Trace element with seed	9	5	2.65	54	16	0.44
	Trace element below seed	7	3	2.71	64	14	0.44
	lsd (P=0.05)	*4*	*NS*	*NS*	*NS*	*NS*	*NS*
Variety (Wharminda)	Schooner Barley	8	-	3.30	66	25	0.42
	Tamaroi Durum	17	19	1.98	59	19	0.39
	Frame Wheat	10	5	2.44	64	20	0.39
	Kukri Wheat	4	7	2.17	54	10	0.46
	2-49 Wheat	4	2	1.44	58	12	0.47
	lsd (P=0.05)	*4*	*5*	*0.31*	*NS*	*8*	*0.05*

[A] In 2000 there was durum at Minnipa, and wheat in Wharminda fertiliser treatments. Durum was in all trials in 2002.

Table 3 : Rotation effects on crown rot inoculum levels, disease and yield of durum wheat in 2002

Minnipa	Crops 2000-2001	Soil Inoculum	Infected Plants (%)	Whiteheads (%)	Yield (t/ha)
Durum 1999 Durum 2002	Pasture-peas	13	17	6	1.45
	Durum-peas	84	49	21	1.32
	Wheat-peas	53	42	13	1.41
	lsd (P=0.05)	*37*	*6*	*4*	*0.08*
Wharminda	Pasture-pasture	58	39	11	0.37
Wheat 1999 Durum 2002	Barley-pasture	210	66	25	0.42
	Durum-pasture	141	59	19	0.39
	Wheat (frame)-pasture	85	64	20	0.39
	Wheat (2-49)-pasture	76	58	12	0.47
	Wheat (kukri)-pasture	77	54	10	0.46
	lsd (P= 0.05)	*NS*	*16*	*8*	*0.05*

What does this mean?

These trials established that stubble burning or cultivation is not reliable for effective crown rot control and a break of at least 2 years between susceptible varieties is needed to significantly reduce inoculum. There was some indication that there was a carryover effect from more resistant varieties which resulted in less disease development and higher yields in subsequent crops. The trials also gave some indication that improved crop vigour from better nutrition will help reduce the effects of crown rot.

The implications from this research are that crown rot management will be best achieved through rotations which maximise the benefits of resistant varieties and break crops and avoid inoculum build-up from intensive use of susceptible varieties. This highlights the need for better yielding resistant varieties for EP and consideration of longer breaks between barley crops which, while tolerant of the disease, can cause more inoculum build up than wheat. Crown rot will also have major implications on the development of durum production on EP and these crops will need to be restricted to paddocks with low inoculum levels.

These trials were designed to identify the best options for reducing crown rot inoculum and set directions for further research in crown rot management. Conventional rotations with current varieties were still the most profitable in the short term because loss to disease was compensated for by their higher yield potential.

Acknowledgments

This work was funded by GRDC and would not have been possible without the valuable assistance of Wade Shepperd (Minnipa Agricultural Centre). SARDI Diagnostic Group provided valuable support in testing soil samples.

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SARDI SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

Pratylenchus Research on Eyre Peninsula

Sharyn Taylor[1], Ali Frischke[2], Michelle Russ[1] and Vivien Vanstone[3]

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Miltaburra sites
Location
Closest Town: Wirrulla
Cooperator: Leon, Marilyn, Carolyn and Darren Mudge
Group: EP Farming Systems and Waite Field Crops Pathology Unit

Rainfall
Ave. annual total: 300 mm
Ave growing season: 212 mm
Actual annual total: 201 mm
Actual growing season: 181 mm

Yield
Potential: 1.92 t/ha

Paddock History:
See Table 1

Soil
Major soil description: Grey, highly calcareous sandy loam

Pests and Diseases
(other than P. neglectus)
Miltaburra Cereal Variety Trial: Mouse damage in most plots. Rhizoctonia patches (particulary in barley plots). Crown Rot (particularly in wheat plots).
Miltaburra Pasture Rotation: Some mouse damage. Rhizoctonia patches.

Plot size
See Table 1.

Other factors
Miltaburra Cereal Variety Trial: Some varieties poorly adapted. Trial drought affected.
Miltaburra Pasture Rotation: All plots badly drought affected.

MAC
Location
Closest Town: Minnipa
Cooperator: MAC
Group: EP Farming Systems and Waite Field Crops Pathology Unit

Rainfall
Ave. annual total: 326 mm
Ave growing season: 241 mm
Actual annual total: 278 mm
Actual growing season: 219 mm

Yield
Potential:2.18 t/ha
Paddock History:
See Table 1

Soil
Land system:
Major soil description:

Pests and Diseases
(other than P. neglectus)
Crown Rot in some wheat plots (particularly WI99069).

Plot size
See Table 1.

Key messages

- **In a rotation trial, highest *P. neglectus* levels were generally found with an increased frequency of Machete or Barque in the rotation. Lowest levels of *P. neglectus* were found with where grass free pasture or Krichauff was sown in 2001.**
- **DNA (Root Disease Testing Service; RDTS) quantifies approximately double the level of nematodes compared with the microscope method.**

Why do the trials?

Cereal Variety Trials: Two-year field trials were sown at Miltaburra and Minnipa Agricultural Centre (MAC) to assess resistance and tolerance to *P. neglectus* in wheat, barley, triticale and oat varieties. Differing *P. neglectus* levels were established in the first year which allowed comparison of varieties in the second year at low, medium and high nematode densities.

Pasture Rotation trial: This trial was initially established in 2000 to assess the effect of grassy pasture, grass free pasture, susceptible wheat, moderately resistant wheat and barley on multiplication of *P. neglectus*.

How was it done?

Cereal Variety trials: In 2001 (first year) susceptible wheat (Frame), and moderately resistant- resistant barley and triticale (Chebec and Tahara) were sown in blocks. In 2002, varieties and lines were sown over these blocks (see Table 1 for sowing and herbicide details). Numbers of *P. neglectus* were determined using both microscope and DNA assays (RDTS in collaboration with Dr Alan McKay). Yield was measured to determine the effect of low and high *P. neglectus* levels on each variety i.e. varietal tolerance.

Pasture Rotation trial: In 2000, plots of grass-free

Table 1: Sowing details and herbicide treatments for P. neglectus trials, 2002

	Cereal Variety trials 2002			Pasture Rotation 2002
	Miltaburra	MAC Oat	MAC Wheat/ barley/ triticale	Miltaburra
Sowing date	30/5/02	5/6/02	5/6/02	31/5/02
Sowing rate	60 kg/ha	60 kg/ha	60 kg/ha	60 kg/ha
Fertiliser	60 kg DAP/ha	60 kg DAP/ha	60 kg DAP/ha	60 kg DAP/ha
Herbicide	Roundup/ Treflan/ Ester (30/5/02); Tigrex (22/8/02)	Roundup (5/6/02) Bromacide Ma (16/8/02)	Roundup/Treflan (5/6/02); Bromacide Ma (16/8/02)	Roundup/Treflan/Ester (31/5/02); Hoegrass (10/7/02); Tigrex (22/8/02)
Seeding depth	3 cm	3 cm	3 cm	3 cm
Plot size	6 x 1.8 m	6 m x 2 m	6 m x 2 m	6 m x 2 m
Trial history	2001: Blocks of Frame, Chebec & Tahara	2001: Blocks of Frame, Chebec & Tahara	2001: Blocks of Frame, Chebec & Tahara	2002 & 2001: Machete, Krichauff, grassy pasture, grass free pasture (Herald) & Barque

pasture (Herald), grassy pasture, barley (Barque) and wheat (Machete and Krichauff) were sown to assess the effects of these crops on multiplication of *P. neglectus*. In 2001, plots were oversown with these treatments so that all crops were tested in all rotation combinations. In 2002, rotations were over-sown with moderately resistant (Krichauff) and susceptible (Machete) wheat. In 2001 and 2002, initial *P. neglectus* levels were measured at seeding using the RDTS. Table 1 shows sowing and herbicide details.

What happened?

Cereal Variety Trials: There were yield losses at both Miltaburra and MAC. Yield results of the intolerant variety, Machete and the tolerant variety, Tahara in the MAC wheat/ barley/ triticale trial are shown in Figure 1. The steeper the downward slope of the line the more intolerant the variety i.e. higher numbers of nematodes result in higher yield loss (Figure 1a). A flatter line indicates higher nematode levels are causing minimal yield loss (Figure 1b). The average yields for each wheat variety following Frame, Chebec and Tahara is shown in Figure 2. When the microscope assay was compared with the DNA assay (RDTS), the DNA method quantified approximately twice the number of nematodes/sample i.e. 10 nematodes /g soil (microscope) = about 20 nematodes/g soil (RDTS) (Figure 2).

At a level of 10 nematodes/g soil (mister) or 20 nematodes/g soil (RDTS), an average of 15% loss for wheat (Machete, Annuello, WI99069, Krichauff and Wyalkatchem) was obtained at MAC (Figure 2).

Yield losses and tolerance ratings for both Miltaburra and MAC sites are shown in Table 2. At MAC, highest yield losses were obtained for Machete and WI99069 (14%). Large yield losses (26%-44%) were also observed in three of the 10 oat varieties/lines tested at MAC (Echidna, SV95057-35 and SV95111-48). At Miltaburra, highest yield losses were obtained for Janz (27%), Machete (12%), WI99069 (14%) and Annuello (7%).

At MAC, average initial *P. neglectus* levels in 2002 were 8, 5 and 2 *P. neglectus* nematodes/g of soil following Frame, Chebec and Tahara respectively. At Miltaburra, initial *P. neglectus* levels in 2002 were 10, 12 and 6 nematodes/g soil following Frame, Chebec and Tahara respectively. At Miltaburra, the high level of multiplication following Chebec was unexpected, and limited the number of low nematode levels required for adequate comparison. Final numbers of *P. neglectus* following all varieties in 2002 (i.e. varietal resistance) are still to be assessed.

Pasture Rotation Trial: At the start of 2002 (i.e after 2 years), rotation was shown to have a large effect on levels of *P. neglectus*. In general, lowest numbers were observed following grass free (Herald) pasture or Krichauff in 2001 and highest numbers following rotations with Machete. Grassy pasture in 2001 maintained the high levels of *P. neglectus* created by Machete in 2002 (Figure 3).

Yield was assessed in the wheat (Machete and Krichauff)

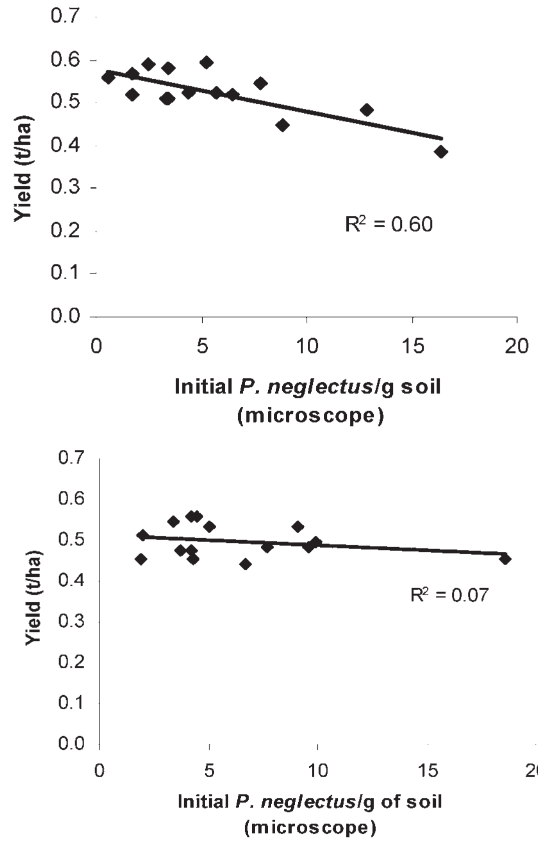

Figure 1: Effect of initial P. neglectus levels on yield for a) the intolerant variety Machete and b) the tolerant variety Tahara at MAC, 2002. P. neglectus numbers assessed using microscope assay. Machete significant at P>0.01 (tabulated r = 0.64); Each data point represents one plot.

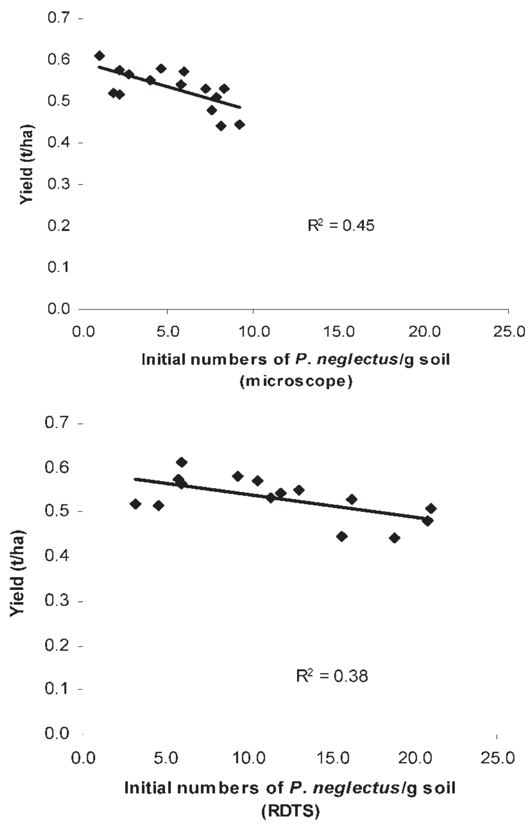

Figure 2: Effect of initial P. neglectus on yield for wheat varieties at MAC 2002. Initial P. neglectus numbers were assessed using a) microscope b) RDTS. Regressions significant at P>0.05 (tabulated r = 0.51); Each data point represents an average of 5 plots for each variety following Frame, Chebec or Tahara sown in 2001.

*Table 2: Yield loss and tolerance ratings to P. neglectus for wheat, barley, oat and triticale varieties/lines at MAC and Miltaburra 2002. 1 P. neglectus assessed at sowing using microscope method; 2 variety sown at Miltaburra only; 3 variety sown at MAC only; * yield loss significant at P>0.05. # = preliminary data (from this trial only).*

Crop Variety/line	Yield loss (%) at 10 *P. neglectus* /g soil[1]	Tolerance Rating	Crop Variety/line	Yield loss (%) at 10 *P. neglectus* /g soil[1]	Tolerance Rating
Wheat			**Barley**		
Machete	13*	I	Sloop	6*	MI
Frame[2]	1	T	Gairdner[3]	7	T
Krichauff	12	MT	Barque	4	T
Annuello[2]	7*	I#	Keel	15	MT
Carnamah[2]	12	MT	Schooner[3]	11	MT
Chara[2]	4	T	SloopVic	8	T#
H45[2]	7	T	SloopSA	7	T#
Janz[2]	27*	I	Dhow[3]	8	T#
Mitre[2]	5	T	Torrens	15*	MI#
Yitpi[2]	0	T	VB0024[3]	1	T#
Wyalkatchem	7	MT			
WI99069	14*	I			
RAC951[2]	11	MT			
RAC964	3	T			
VO1225[2]	2	T#			
VO2180[2]	4	T#			
Oat			**Triticale**		
Echidna[3]	26 *	I	Tahara	0	T
Euro[3]	11	MT	Treat[3]	8*	MI#
Potoroo[3]	7	T	Tickit[3]	1	T#
SV91024-7[3]	17	MT#			
SV93081-21[3]	11	MT#			
SV94046-57[3]	12	MT#			
SV95057-35[3]	33*	I#			
SV95110-12[3]	0	T#			
SV95111-48[3]	44 *	I#			
SV95149-39[3]	7	T#			

plots over-sown across the rotation treatments in 2002. There was no correlation between *P. neglectus* levels and yield, as this trial was very drought stressed with an average yield/plot of 0.15 t/ha. Drought therefore appeared to be the overriding factor affecting yield. However, assuming 10 nematodes/g soil (measured using RDTS) causes approximately 7% yield loss in intolerant varieties (from the previous section), eight of the 25 rotations assessed had the potential to result in significant yield losses. In these eight rotations, the frequencies (highest to lowest) of the five crops/pastures assessed in 2002/2001 were as follows: susceptible wheat (6), barley (4), grassy pasture (3), grass free pasture (2) and moderately resistant wheat (1). Highest *P. neglectus* levels were therefore most likely to occur with susceptible wheat in the rotation.

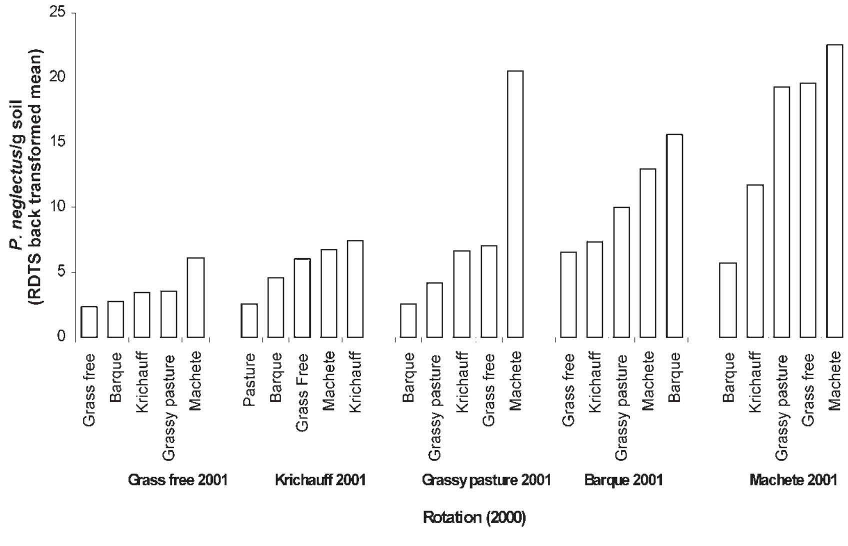

Figure 3: Initial numbers of P. neglectus/g soil assessed at sowing in 2002 using DNA assay (RDTS). Bars indicate P. neglectus levels following different rotational combinations in 2000 (listed under each bar) and 2001.

Acknowledgments

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Managing Soil-borne Diseases Using Precision Agriculture

John Heap,

SARDI, Field Crops Pathology Unit, Plant Research Centre, Waite

Key Messages Box

- **Soil-borne diseases often limit yield and drive rotations.**
- **Precision Agriculture techniques can divide paddocks into management zones, based on data layers such as yield maps, electro-magnetic (EM) maps, satellite imagery etc.**
- **New SARDI/GRDC research shows that diseases are often concentrated in some management zones more than others within a paddock.**
- **Precision Agriculture is developing rapidly in Australia and overseas, offering the potential to manage diseases differently within certain zones within paddocks.**

Why do the trial?

To understand how soil-borne diseases are distributed within paddocks in relation to Precision Agriculture management zones, and to investigate how this can be used to improve soil sampling, optimise paddock management, and increase profits.

Soil-borne diseases are not distributed uniformly across paddocks, yet paddocks are currently managed uniformly. This means that some areas within paddocks receive sub-optimal management. This research aims to learn more about how soil-borne diseases are distributed within paddocks. This information will improve soil sampling for diseases (using the Predicta B tests), and provide the economic modelling basis for future Site Specific Management (SSM) of diseases (e.g. using variable rate technology - VRT). Precision Agriculture technology is developing rapidly in Australia and overseas, and anyone interested in finding out more can contact the Southern Precision Agriculture Association (SPAA) via Brendan Frischke (SARDI, MAC).

How was it done?

Yield and EM maps (proximally-sensed data layers) were collected for 22 cropping paddocks across SA in 2002. Precision Agriculture techniques were used to divide the paddocks into management zones and then separate soil samples (unreplicated) were taken from each zone. Soil was tested for DNA of CCN, take-all, Pratylenchus neglectus, Pratylenchus thorneii, rhizoctonia, crown rot and blackspot. Seven paddocks were chosen for more intensive study, involving comparison of management zones based on satellite biomass imagery with zones based on yield and EM maps. Five soil samples (five replicates) were taken from each zone to compare differences in disease distribution between the various zones. In one of the seven paddocks satellite imagery was the only data available.

What happened?

Results from the first survey showed that in all of the 22 paddocks at least one disease was present at different risk categories between the management zones within the paddock. This suggests that it is very common for soil-borne disease inoculum to occur in patches which coincide with Precision Agriculture management zones. An example of this is given for the North 12 paddock at MAC (Figure 1), where three yield maps, an EM map and an elevation map are used to define three management zones which were found to contain different levels of soil-borne disease inoculum.

The results from comparing management zones derived from proximally-sensed data (e.g. yield and EM maps) with zones derived from satellite data for seven paddocks are shown in Table 1. In Table 1, “case” refers to study of a disease’s distribution in a particular paddock. Overall, zones based on satellite data described differences in inoculum distribution (20/25 cases) better than proximally-sensed data (8/23 cases). There appears to be no clear general correlation between the yield potential or yield stability of a zone with disease inoculum level. This means that the distribution of disease inoculum within a paddock is complex, and will need to be understood for each disease through further research and analysis.

What does this mean?

This research has opened up an exiting possibility of measuring and managing soil-borne diseases more efficiently using Precision Agriculture, but it is clear that agronomic interpretation of the complex disease distribution patterns will require much more work. Soil sampling for disease inoculum testing will be improved by selecting a representative set of sampling points across the management zones identified. In the future, knowledge of inoculum distribution may be used to target more or less inputs (eg N) into different zones using VRT. It may also be possible to manage diseases directly using VRT, for example sowing more expensive treated seed into only those areas within a paddock known to have a high take-all risk.

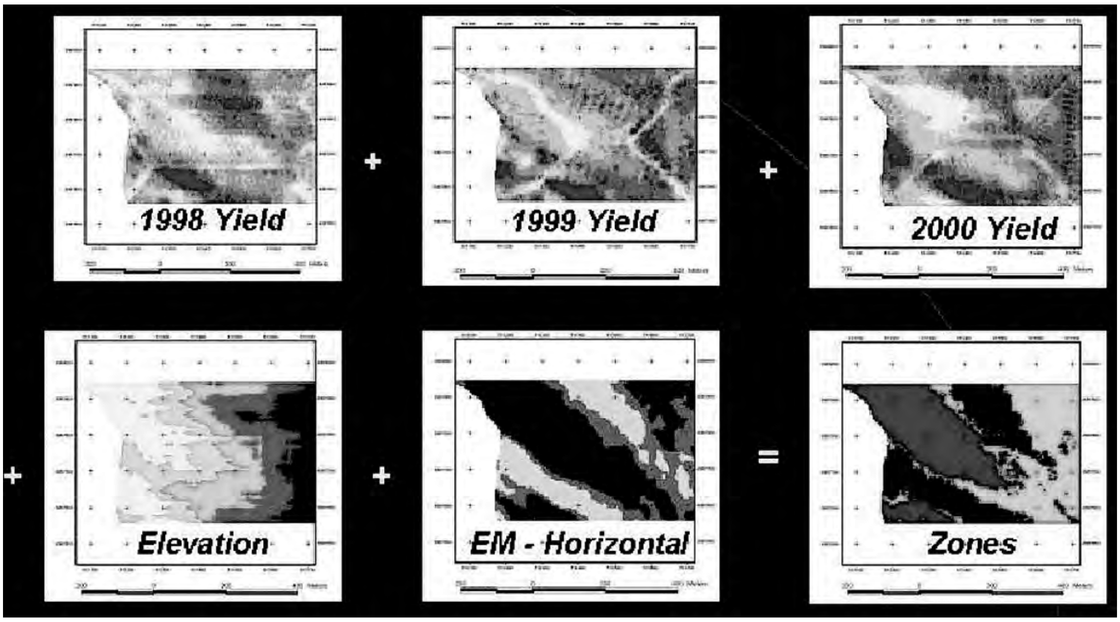

Figure 1: Three yield maps, an elevation map and an EM map are combined to define three management zones (bottom right) for the North 12 paddock at Minnipa Agricultural Centre. Testing of soil from the zones showed that Pratylenchus negelctus, P. thorneii and crown rot were concentrated in the mid-tone zone, while take-all was spread evenly across the zones. Rhizoctonia was medium to high in the light and medium-tone zones, but not detected at all in the dark-tone zone.

Table 1: Number of cases of significant measured differences in disease inoculum between management zones for seven paddocks in 2002.

Disease*	Zones from proximally-sensed data		Zones from satellite/yield stability data		Yield class (satellite data) in which the highest disease inoculum level is measured				
	Cases tested	Cases different	Cases tested	Cases different	Low	Med	High	Stable	Unstable
bs	3	1	3	3	1	0	2	1	2
ccn	2	0	2	2	1	1	0	1	1
cr	1	0	2	1	0	0	1	0	1
pn	5	2	6	6	3	0	3	2	4
pt	5	3	4	3	2	0	1	1	2
rs	4	2	5	2	1	1	0	2	0
ta	3	0	3	3	0	2	1	2	1
Total	**23**	**8**	**25**	**20**	**8**	**4**	**8**	**9**	**11**

**Disease: bs=blackspot; ccn=cereal cyst nematode; cr=crown rot; pn=Pratylenchus neglectus; pt= Pratylenchus thorneii; rs=rhizoctonia; ta=take-all.*

Acknowledgements

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Colleagues and growers are thanked for their kind provision of assistance and data.

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Key to symbols

Section

6

Section Editors: ***Nigel Wilhelm***
Research Leader
and Jon Hancock
Farming Systems Researcher
Minnipa Ag Centre

Nutrition

Improved nutrition is one of the key factors driving increased crop production in low rainfall areas. In 2002, fluid phosphorus fertilisers have continued to outperform granular alternatives on phosphorus responsive calcareous soils but it is becoming clear that other nutrients are also required in the mix for the best responses. This research is now at the stage where some farmers in the most fluid P responsive areas are already adapting machinery to suit fluid fertiliser application. Farmers outside these areas are watching developments very closely to see if there is something in it for them as well.

This section focuses on the latest in fluid fertiliser research, cheaper application methods for fertilisers, soil chemistry, the role of nitrogen, row spacing, water rates and farmer experiences. Other interesting articles discuss trace elements and selenium in wheat to prevent cancer.

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Soil Chemistry of Fluid and Granular Phosphorus Fertilisers

Enzo Lombi[1]*, Mike McLaughlin*[1]*, Roger Armstrong*[2] *and Bob Holloway*[3]

[1] *CSIRO Land and Water, Adelaide;* [2] *VIDA Horsham;*

[3] *SARDI, Minnipa Agricultural Centre*

Why do the study?

Until very recently the efficiency of fluid and granular fertilisers was considered to be equal. However, field trials conducted in the Eyre Peninsula have showed that in calcareous soils significant increases in yields can be achieved using fluid fertilisers such as ammonium polyphosphate (APP). The chemical mechanisms responsible for this difference between fluid and granular fertilisers are difficult to study under field conditions. Therefore, a series of pot and laboratory experiments has been conducted at CSIRO Land and Water, Adelaide. We have used isotopic dilution techniques to investigate the availability, diffusion and distribution of phosphorus in and around granules of fertilisers and bands of fluid fertilisers. Furthermore we have used advanced microscopic methods, such as energy dispersive X-ray microanalyses (EDXMA) and bulk X-ray diffraction, to study the distribution and mineralogy of phosphorus in fertiliser granules incubated in soil for different periods of time. The final aim of this project is to gain information that will allow us to explain why some phosphorus fertilisers perform better than others in soil and to predict which is the best form of fertiliser to be used in a specific soil type.

How was it done?

We have tried to answer these two questions:

- Why are fluid polyphosphates effective in calcareous soils?
- Is it the slow rate at which granular fertilisers dissolve that is responsible for their low efficiency?

During the course of our research, we noted that polyphosphates are particularly effective in highly calcareous soils from the point of view of phosphorus nutrition and phosphorus chemistry. Three granular P-fertilisers: monoammonium phosphate (MAP, 10:22), diammonium phosphate (DAP, 18:20), triple superphosphate (TSP, 0:20) and three liquid P-fertilisers: technical grade MAP (TGMAP, 12:26), ammonium polyphosphate (APP, 13:20 1%Zn), and orthophosphoric acid (H_3PO_4, 0:27) were compared at a single application rate of 60 kg/ha of P. A grey calcareous soil from the Eyre Peninsula was used in this study. A technique using a radioisotope of phosphorus was used to calculate how much of the applied fertilisers had been "fixed" in the soil and unavailable for plant uptake after 5 weeks of growth by the wheat plants.

An experimental design using petri dishes was developed to allow examination of soil chemistry at increasing distance from the fertilized bands (in the case of fluids) or fertilizer granules. Increasingly large concentric rings of soil were removed from around the fertilized zone after 5 weeks of incubation in a grey calcareous soil from the Eyre Peninsula. Radio-isotopic techniques and spectroscopic methods (X-ray microanalyses, X-ray diffraction) were used for the determination of chemical changes of P in the soil and for examination of granules.

What happened?

P in all three granular products was rapidly fixed into non-plant available forms. In only 5 weeks more than 60% of added P was fixed. In contrast, all the fluid products remained relatively available in the soil. In addition, phosphoric acid (H_3PO_4) and ammonium polyphosphate (APP) actually mobilised native phosphorus from the soil (Figure 1).

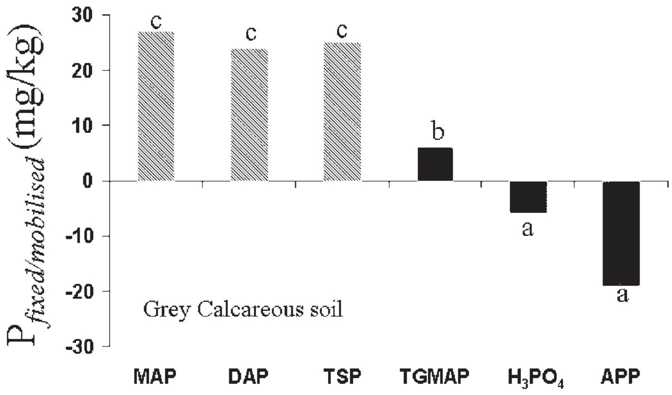

Figure 1: Fixation or mobilisation of P added in granular and fluid fertilisers. Columns greater than zero indicate fixation, and columns below zero indicate mobilisation of native P in soil. Columns appended by the same letter are not significantly different at P=0.05.

The mechanisms to explain these effects are

a) the slight mobilisation by phosphoric acid is likely to be due to localised acidification in the fertilised band in the soil, dissolving calcium phosphates, and

b) the marked mobilisation noted with APP is most likely due to this fertiliser dissolving calcium phosphates by complexation (similar to how trace element chelates work).

Computer simulations of the polyphosphate effect using a soil chemistry model confirmed that complexation may explain the mobilisation of the soil P bank observed in the wheat growth experiments. Modelling runs indicated that addition of ammonium polyphosphate to a "model" soil system caused calcium phosphate to dissolve. Much of the soil P bank in Upper EP soils is comprised of calcium phosphates.

Reactions around the fertiliser zone

Examination of total phosphorus concentrations in the various zones around the granule or fertilised zone indicated a very different distribution of P in the zones depending on whether MAP was supplied in granular or liquid form (Figure 2). When MAP was supplied in granular form, much more of the P in the petri dish system was concentrated in the first zone around the granule itself (0-7 mm). Supply of MAP in fluid form (TGMAP) allowed much more of the phosphorus to diffuse away from the fertilised zone (0-7 mm), into outer sections of soil (7-13 and 13-25 mm).

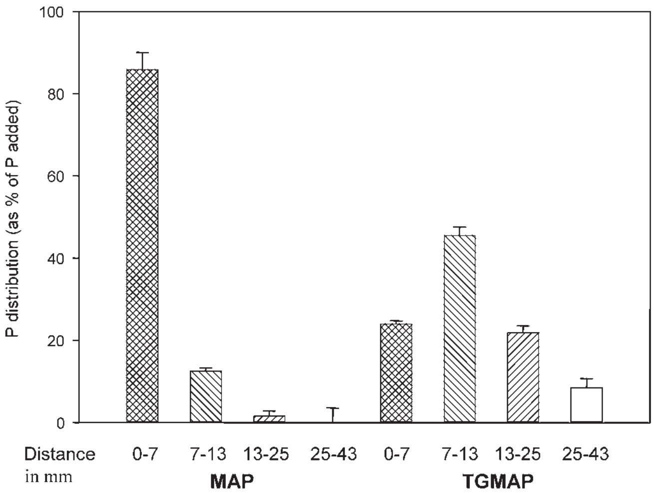

Figure 2: Amounts of P in four soil zones around a MAP fertiliser granule and a fluid TGMAP-fertilised zone, expressed as a % of total P applied with the fertiliser. Equal amounts of P were supplied with both formulations to a grey calcareous soil.

Scanning electronic microscopy and X-ray microanalysis of the granule before and after incubation in soil indicated that a significant amount of P was still in the granule together with large concentrations of calcium, aluminium and iron. The crystalline form of P in the granules after incubation was examined using X-ray diffraction, and several crystalline phases were identified, including the poorly soluble mineral crandallite ($CaAl_3(PO_4)_2(OH)_5\Sigma(H_2O)$).

What does this mean?

It is possible that on many of the calcareous soils of southern Australia, responses to P have not been recorded because of the inability of plants to respond to granular sources of P within economic limits of application. It is evident that large amounts of precipitated P have built up in these soils over the many years of fertilisation with granular products, with total P concentrations in many of these soils being very high (Bertrand et al. 2002), despite available P being low as evidenced by P deficiency symptoms in plants. The conclusion that some of these soils are not P responsive may in fact be due to the form of P used, rather than P deficiency not being present.

The results of our work to date have indicated that there is a sound basis in terms of soil chemistry for the greater efficiency of fluid fertilisers on calcareous soils. In fact, the range of soils able to benefit from fluid applications of P is likely to increase (e.g. soils in the Upper north with high levels of total P but relatively low levels of available P) with our improved understanding of the chemistry of fertiliser reactions in soils, using a combination of radiotracer and spectroscopic methods. An understanding of the reasons why products behave differently in different soils is an essential prerequisite to developing low cost and effective fertilisers. For instance, our data on the chemistry of ammonium polyphosphate (APP) reactions with both grey and red calcareous soils implies that the effectiveness of ammonium polyphosphates in mobilising fixed P may extend to other soils with the same P fixing characteristics.

Farmers may finally have a technique to easily access the “super bank” in these soils. Furthermore, it appears that part of the P contained in granular fertilisers may not be soluble under the extremely alkaline conditions of soils on upper Eyre Peninsula.

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CSIRO

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FLUID FERTILIZER FOUNDATION

SAGIT

How Much Fluid P Fertiliser is Enough?

Bob Holloway, Alison Frischke and Dot Brace

SARDI, Minnipa Agricultural Centre

Location
Emerald Rise
Closest town: Poochera
Cooperator: Reg, Nigel & Dion Brace

Rainfall
2002 Annual total: 198mm
2002 growing season: 168mm

Yield
Potential: 1.16 t/ha

Soil
Red, brown calcareous sandy loam
8.6% Calcium carbonate
38 mg/kg Colwell P

Plot size
Small plots (15m x 6 rows x 2 reps)

Other factors
Dry period August-September

Key Messages

- **Fluid fertilisers usually produced higher yielding cereal crops than granular fertiliser, even in the absence of P deficiency**
- **APP produced similar cereal yields to acidified APP but trace element nutrition was often enhanced by acidifying APP.**
- **The cheaper fluid fertilisers (phosphoric acid and acidified APP) usually matched the financial performance of granular fertiliser and in some instances provided substantial additional profits**

Why do the trial?

To compare the yield and gross margin performance of two fluid and one granular fertiliser at various phosphorus rates.

We wanted to know whether lowering the pH of ammonium polyphosphate (APP) from 6.5 down to about 2 with phosphoric acid would keep zinc and/or manganese sulphate in solution - the sulphates are the cheapest sources of trace elements but they are not very soluble at neutral-alkaline pHs. However, a risk with acidifying APP is that acid conditions may break APP down to the same simple form of phosphate as occurs in phosphoric acid. About 60% of the phosphorus (P) in fresh APP is in a complex long chain molecular form called polyphosphate. We think that these polyphosphates may be the reason that APP is so effective as a P fertiliser in calcareous soils.

It is not possible to add much zinc (Zn) or manganese (Mn) sulphate to fresh APP fertilisers, particularly manganese sulphate. A small amount of Zn sulphate can be added to APP but it is very easy to add too much and form a thick sludge which will block filters and nozzles and the mix won't flow out of the tank. Zn and Mn chelates can be mixed with APP without too many problems although if this is done, make sure to prepare enough mix for that day only and don't leave a mixed tank overnight. The mixture of chelated Zn and Mn with APP is very effective at getting these micronutrients into the plant and doesn't seem to affect the performance of the APP. However, the chelates are much more expensive than sulphates, although they may be effective at lower rates. The problem is, we don't know what the comparative rates are - we're planning to do research on this in 2003.

The main purpose of the trials this year was to see if mixing phosphoric acid with APP, with 30-45% of the total P supplied by the acid (depending on the site), would reduce the effectiveness of APP as a fertiliser or increase its compatibility with sulphate sources of trace elements.

EMERALD RISE

How was it done?

Method:

- All plots were sown with Krichauff wheat on 3 June with all fertilisers placed below the seed.
- All plots received 18 kg N and 2.2 kg Zn/ha.

Treatments:

- 9 rates of P (0, 2, 4, 6, 8, 10, 12, 14, 16 kg P/ha)
- 3 sources of fertiliser (2 fluid & 1 granular)

At Emerald Rise, plants need Zn more than Mn, so Zn sulphate was either mixed direct with the acidified APP (plus urea), or was applied at the same time as fresh APP through a separate pump and lines. In this case, Zn sulphate was acidified with citric acid to apply it at the same pH as in the acidified APP. In the granular treatment, Zn was applied as a coating on 18:20 and urea (16:18 Zn2.5% + urea5%).

- **Fluid APP**: ammonium polyphosphate (14:21) + UAN with Zn sulphate applied in a separate solution
- **Fluid Acidified APP**: ammonium polyphosphate (14:21) + phosphoric acid + urea + Zn sulphate applied in one solution
- **Granular:** 16:18 Zn2.5% + urea Zn5%

Measurements:

Early dry matter production, tiller counts, whole plant tissue analysis, grain yield, protein, grain analysis, grain yield parameters.

What happened?

Sowing at Emerald Rise was done in moist soil but only 168 mm of rain was received in the growing season. After the end of July, there was no useful rain for the rest of the season. Plants were sampled for dry matter early in August. Growth responses to APP and acidified APP were similar. At a P application rate of 8 kg/ha, acidified APP produced 87% higher dry weight of shoots than the granular fertiliser (Fig.1).

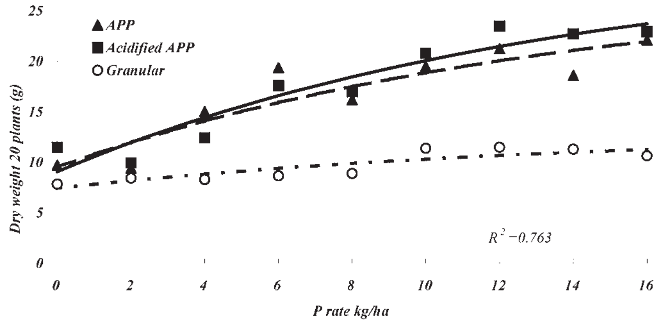


Figure 1: Response of Krichauff wheat shoots at tillering to increasing rates of P applied as either granular, APP or acidified APP at Emerald Rise, 2002.

Zn concentration in whole shoots and the total amount of Zn in shoots (uptake) at tillering were increased with acidified APP plus Zn sulphate compared to fresh APP and zinc sulphate applied separately. The uptake of Zn was also improved with APP compared with granular fertiliser. Phosphorus uptake in plants treated with either fluid fertiliser were about 70% higher than in granular treated plants, regardless of the rate of product used (Table 1).

Table 1: Zn and P concentrations and uptake in shoots of Krichauff wheat as a result of fertiliser applied at Emerald Rise, 2002. Each value in the table is an average for all 9 rates of applied product.

	Zn concentration (mg /kg)	P concentration (mg /kg)	Zn uptake (g/ha)	P uptake (kg/ha)
Acidified APP	22.4	1843	19.5	1611
APP	18.9	1838	15.7	1541
Granular	19.0	1955	9.2	946
LSD (P=0.05)	1.2	69	2.1	194

Grain yield responses are shown in Fig.2. At a rate of 8 kg P/ha, APP and acidified APP produced 36% more grain than the granular fertiliser treatment. A symptom of P deficiency is poor tillering. On average, the two fluid treatments produced 18% more fertile tillers than the granular treatment and the fluid treated grain was 2% heavier on average. Grain proteins were 13.1% with acidified APP, 12.7% with APP and 12.0% with granular.

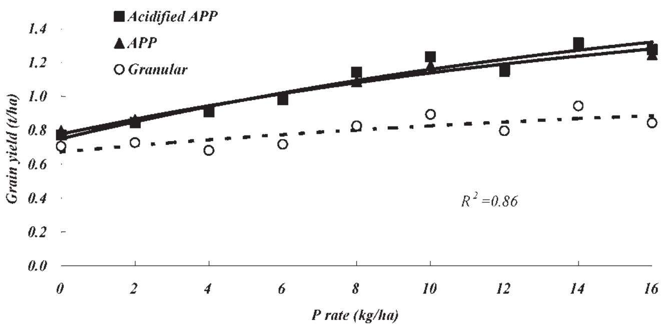


Figure 2: Response of grain yield of Krichauff wheat to increasing rates of P applied as granular, APP or acidified APP at Emerald Rise, 2002.

Adding acid to APP did not affect P concentration in grain compared with APP but increased Zn concentration by 13%. Concentrations of Zn and P in grain are shown in Table 2.

Table 2: Effect of fertiliser type on Zn and P concentrations in grain of Krichauff wheat at Emerald Rise, 2002. Each value in the table is an average for all 9 rates of applied product.

	Zn concentration (mg Zn/kg)	P concentration (mg P/kg)
Acidified APP	20.0	1854
APP	16.8	1832
Granular	14.4	1758
LSD	1.1	75

Total P uptake in grain was similar with acidified APP and APP (Fig.3), but Zn uptake in grain was increased further by acidifying APP (Fig.4).

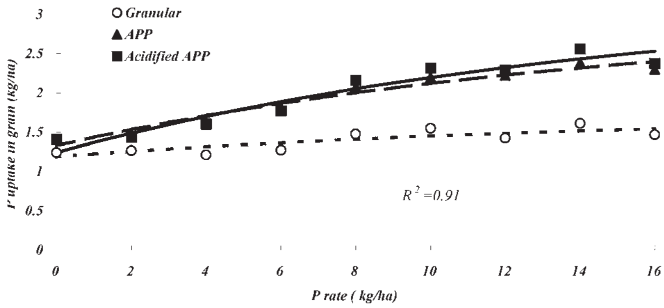


Figure 3: Response of P uptake in grain of Krichauff wheat to fertiliser type and P rate at Emerald Rise, 2002.

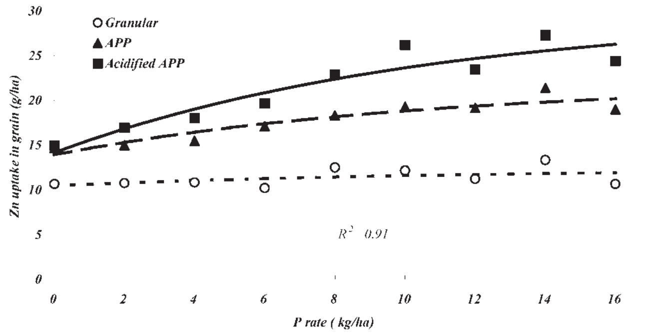


Figure 4: Response of Zn uptake in grain of Krichauff wheat to fertiliser type and P rate at Emerald Rise, 2002.

WARRAMBOO

How was it done?

Method:

- All plots were sown with Krichauff wheat on 29 May with all fertilisers placed below the seed
- All plots received 23 kg N, 1.5 kg Zn, 3.2 kg Mn & 1 kg Cu/ha.

Treatments:

- 9 rates of P (0, 2, 4, 6, 8, 10, 12, 14, 16 kg P/ha)
- 3 sources of fertiliser (2 fluid & 1 granular)
- **Fluid APP**: ammonium polyphosphate (14:21) +

Location
"White Well"
Closest town: Warramboo
Cooperator: Tim & Tracey van Loon

Rainfall
Av. Annual total: 350 mm
2002 Annual total: 206 mm
2002 growing season: 153 mm

Yield
Potential: 0.86 t/ha

Soil
Grey highly calcareous sandy loam
60% Calcium carbonate
32 mg/kg Colwell P

Plot size
Small plots (15m x 6 rows x 2 reps)

Other factors
Dry period August-September

UAN with Zn, Mn and copper (Cu) sulphate applied in a separate solution

- **Fluid Acidified APP:** ammonium polyphosphate (14:21) + phosphoric acid + UAN with Zn, Mn and Cu sulphate applied in a separate solution
- **Granular:** 13:15 Mn6% + urea Zn5% + Cu sulphate

Measurements:

Early dry matter production, grain yield, grain analysis, protein.

What happened?

Krichauff wheat plots were sown into moist soil at Warramboo, but the season was similar to that at Emerald Rise, with 153 mm of growing season rainfall between April and October. At this site, two sulfonylurea herbicides were used to control a post-sowing emergence of wild oats and brome grass (this was done to "save" the trial and is not a recommended practice). As a consequence of this, the root systems on all plants were very stunted. There were visible differences between treatments until August however and the nature of these is shown in Fig.5.

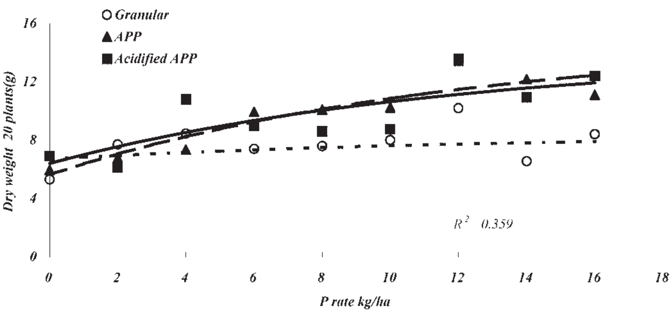


Figure 5: Response of Krichauff wheat shoots at tillering to increasing rates of P applied as either granular, APP or acidified APP at Warramboo, 2002.

By harvest, the differences between the fertiliser treatments were not as visible as earlier in the season, although there was a 48% increase in yield from nil P (0.56 t/ha) to 16 kg P/ha (0.83 t/ha), averaged for all of the fertilisers. Average grain yield for acidified APP was 0.72 t/ha, for APP 0.67 t/ha and for granular 0.59 t/ha, an average benefit in yield of 17% from the use of fluid fertiliser rather than granular. The conclusion from this is that early in the season, there was enough moisture for the individual fertilisers to make a difference in growth as increasing amounts of phosphorus were applied but by harvest, moisture was the major limiting factor. The early differences were still sufficient to affect the average yields so that acidified APP was the highest overall.

Zn concentrations in grain were higher with APP than with granular, but there were no differences in P concentrations in grain. All concentrations were low. Zn and P uptake in grain were higher with both fluid treatments than with granular (Table 3).

Table 3: Effect of fertiliser type on Zn and P concentrations and total uptake in grain of Krichauff wheat at Warramboo, 2002. Each value in the table is an average for all 9 rates of applied product.

	Zn concentration (mg /kg)	P concentration (mg /kg)	Zn uptake (g/ha)	P uptake (kg/ha)
Acidified APP	14.7	1837	10.8	1.33
APP	15.4	1896	10.6	1.28
Granular	13.7	1843	8.3	1.10
LSD	1.1	ns	1.8	0.15

ELLISTON

How was it done?

Method:

- All plots were sown with Sloop barley on 8 August with all fertilisers placed below the seed All plots received 23 kg N, 1.5 kg Zn, 3.2 kg Mn & 1 kg Cu/ha.
- All plots received a stream bar application of UAN @ 40 kg N/ha at late tillering. Until this time, fluid treated plots were clearly more vigorous and taller, but they began to show symptoms of nitrogen deficiency so all plots (including the granular) were treated with UAN.

Treatments:

- 9 rates of P (0, 2, 4, 6, 8, 10, 12, 14, 16 kg P/ha).
- 3 sources of fertiliser (2 fluid & 1 granular).
- **Fluid APP:** ammonium polyphosphate (14:21) + UAN with Zn, Mn, Cu sulphate applied in a separate solution.

Location
"Warna"
Closest town: Elliston
Cooperator: Keith & Julie Tree

Rainfall
Av. Annual total: 417mm
Av. Growing season: 343mm
2002 Annual total: 357mm
2002 growing season: 309mm

Yield
Potential: 3.98 t/ha

Soil
Grey calcareous
40% Calcium carbonate
72 mg/kg Colwell P

Plot size
Small plots (15m x 6 rows x 2 reps)

Other factors
Sown on heavy wheat stubble

- **Fluid Acidified APP**: ammonium polyphosphate (14:21) + phosphoric acid + UAN with Zn, Mn, Cu sulphate applied in a separate solution.
- **Granular**: 13:15 Mn6% + urea Zn5% + copper sulphate.

Measurements:

Early dry matter production, tiller counts, whole plant tissue analysis, grain yield, protein, grain analysis, grain yield parameters.

What happened?

Rainfall was below average but the site still received 309 mm for the growing season. Acidified APP and APP produced similar dry weights of shoots early in August. At 6 kg P/ha, the average increase in dry weight of shoots produced by the fluid fertilisers compared with the granular was 59% (Fig.6).

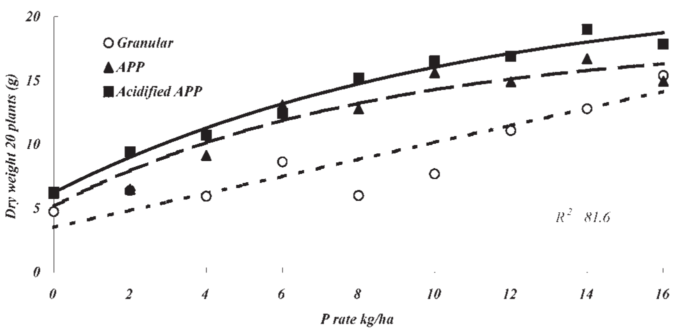


Figure. 6: Response of Sloop barley shoots at tillering to increasing rates of P applied as either granular, APP or acidified APP at Elliston, 2002.

P concentrations in shoots were similar with the three fertiliser types, but the uptake of P by whole shoots was greatest with the acidified APP treatment. Acidified APP treated plants had a higher concentration of Zn than granular treated plants but all were in the adequate range. Zn uptake was higher with APP than granular, and higher again with the acidified APP treated plants (Table 4).

Table 4: Effect of fertiliser type on Zn and P concentrations and total uptake in shoots of Sloop barley at Elliston, 2002. Each value in the table is an average for all 9 rates of applied product.

	Zn concentration (mg Zn/kg)	P concentration (mg P/kg)	Zn uptake (µg Zn/plant)	P uptake (µg P/plant)
Acidified APP	18.4	2588	12.8	1833
APP	18.1	2584	10.9	1672
Granular	17.2	2448	7.2	1054
LSD	0.9	ns	0.1	96

There were no differences between fertiliser types in terms of the rate of response of grain yield to increasing P application rates. However, the overall average yield for acidified APP was 2.19 t/ha, for APP 2.1 t/ha and for granular 1.80 t/ha, a difference between acidified APP and granular types of 21%. It is interesting to note that even when no P was applied, the yield difference between acidified APP and granular treatments was 30%. In these treatments, only micronutrients and N were applied; either as fluid (UAN with sulphates in separate solutions) or granular (sulphates with urea granules). This suggests that the increase in response over the whole range of P application rates was probably due to the fluid N or the fluid N/micronutrient combination.

The form of fertiliser used had no effect on P, Zn or Mn concentrations in grain, but the total removal of P and Zn in grain (uptake) was higher with fluid fertilisers than with granular, due to higher yields (Table 5). The overall average grain concentration of Mn was 31.8 mg/kg.

Location
Miltaburra
Closest town: Wirrulla
Cooperator: L & M Mudge

Rainfall
Av annual total: 305 mm
Av growing season: 235 mm
2002 total: 235 mm
2002 GSR: 191 mm

Yield
Potential: 1.62 t/ha

Soil
Grey highly calcareous sandy loam
52% Calcium carbonate
40 mg/kg Colwell P

Plot size
15m x 1.4m x 2 reps

Table 5: Effect of fertiliser type on Zn and P concentrations and total uptake in grain of Sloop barley at Elliston, 2002.

	Zn concentration (mg /kg)	P concentration (mg/kg)	Zn uptake (g/ha)	P uptake (kg/ha)
Acidified APP	18.2	2617	39.3	5.61
APP	18.0	2556	37.3	5.36
Granular	17.6	2484	30.8	4.37
LSD	ns	ns	3.2	0.54

MILTABURRA, PENONG RED, PENONG GREY

This set of trials were specifically requested by farmer groups as part of the EP Farming Systems project to estimate gross margins for various products at different P rates. That information is presented in the following figures, however readers are reminded that these gross margins are presented with only one year's worth of data. For reliable decisions we need to continue these trials over a number of seasons and soil types.

How was it done?

Method:

- All plots were sown with Krichauff wheat on 30 May, 2 and 3 June for Miltaburra, Penong Red and Penong Grey, respectively.
- All fertiliser was placed below the seed and all plots received 12 kg N and 1 kg Zn/ha.

Treatments

- 9 rates of P (0, 2, 4, 6, 8, 10, 12, 14, 16 kg P/ha).

Location
Penong Red
Closest town: Penong
Cooperator: B & L Oats

Rainfall
Av annual total: 318 mm
Av growing season: 215 mm
2002 total: 213 mm
2002 GSR: 187 mm

Potential Yield
1.54 t/ha (wheat)

Soil
Red calcareous sandy loam
14% Calcium carbonate
27 mg/kg Colwell P

Plot size
15m x 1.4m x 2 reps

Location
Penong Grey
Closest town: Penong
Cooperator: G & M Michelle

Rainfall
Av annual total: 254 mm
Av growing season: 190 mm
2002 total: 192 mm
2002 GSR: 161 mm

Potential Yield
1.02 t/ha (wheat)

Soil
Grey highly calcareous sandy loam
76% Calcium carbonate
40 mg/kg Colwell P

Plot size
15m x 1.4 m x 2 reps

- 3 sources of fertiliser (2 fluids, 1 granular).

- **Fluid APP:** ammonium polyphosphate (14:21) + UAN + Zn chelate.

- **Phosphoric Acid:** phosphoric acid + urea + Zn sulphate.

- **Granular:** 18:20 + 0:20 +urea + Zn sulphate.

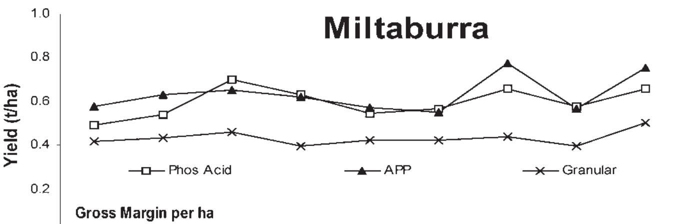
Measurements:

early dry matter production, tissue analysis, grain yield, protein.

What happened?

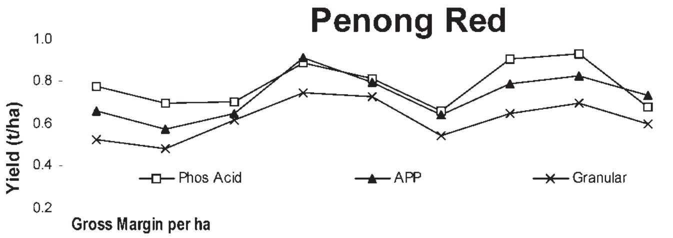
Crop responses to increasing rates of P fertiliser were unreliable at Miltaburra (Figure 7). However, treating with fluid fertilisers always gave better yields than those achieved with granular fertiliser. Both fluid fertilisers gave similar yields with an average advantage over granular of 0.18 t/ha (or 42%). The advantage of fluid treatments over granular still held in the absence of added P which suggests that the N and zinc component of the fluid mixes also conferred some advantages to wheat growth.

The performance of Krichauff at the Penong Red site also showed this pattern of fluid fertilisers producing better wheat yields right across the range of applied P levels, including no P (Figure 8). The average advantage of fluids over granular were 0.14 t/ha or 22% The impact of increasing rates of applied P was also not very clear.



P Rate	0	2	4	6	8	10	12	14	16
Phos Acid	$ 21.77	$ 26.35	$ 59.88	$ 35.52	$ 7.69	$ 6.22	$ 21.57	-$ 5.49	$ 8.51
APP	-$ 24.59	-$ 19.11	-$ 21.78	-$ 37.96	-$ 56.97	-$ 70.83	-$ 22.93	-$ 82.87	-$ 43.80
Granular	$ 2.91	$ 4.51	$ 8.99	-$ 10.06	-$ 6.25	-$ 9.85	-$ 8.73	-$ 22.13	$ 0.07

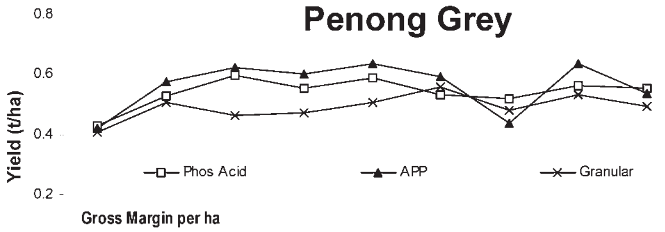
Figure 7: Response of Krichauff wheat shoots at tillering to increasing rates of P applied as either granular, APP or Phosphoric acid at Miltaburra, 2002. Table contains gross margins for each treatment.



P Rate	0	2	4	6	8	10	12	14	16
Phos Acid	$ 98.01	$ 71.14	$ 65.51	$ 104.42	$ 78.70	$ 33.98	$ 89.19	$ 88.46	$ 17.43
APP	$ 1.50	-$ 28.57	-$ 18.17	$ 39.65	$ 3.15	-$ 43.49	-$ 15.31	-$ 13.64	-$ 44.16
Granular	$ 38.83	$ 21.71	$ 52.51	$ 82.01	$ 74.35	$ 25.67	$ 48.80	$ 58.02	$ 28.65

Figure 8. Response of Krichauff wheat shoots at tillering to increasing rates of P applied as either granular, APP or Phosphoric acid at Penong Red, 2002.

At the Penong Grey site, there were clear benefits in wheat growth to the application of P fertiliser. All fertiliser types increased the grain yield of Krichauff with the largest yield increase of 0.16 t/ha or 38% occurring at 8 kg P/ha. Although fluid fertilisers resulted in higher grain yields at all P rates, the average advantage of fluid fertilisers was only 0.06 t/ha or 11%.



P Rate	0	2	4	6	8	10	12	14	16
Phos Acid	$ 49.28	$ 67.59	$ 78.30	$ 60.66	$ 62.12	$ 41.46	$ 30.96	$ 35.54	$ 26.66
APP	-$ 20.18	$ 11.15	$ 15.69	$ 1.39	$ 2.51	-$ 16.67	-$ 63.70	-$ 22.05	-$ 54.27
Granular	$ 44.69	$ 67.96	$ 53.92	$ 52.45	$ 58.75	$ 69.22	$ 46.71	$ 55.59	$ 42.05

Figure 9: Response of Krichauff wheat shoots at tillering to increasing rates of P applied as either granular, APP or Phosphoric acid at Penong Grey, 2002.

What does this mean?

Phosphoric acid was mixed with APP to provide up to 45% of the total P supplied without detriment to the performance of APP.

At Emerald Rise, the mixture of APP, urea, phosphoric acid and Zn sulphate was very successful. Zn uptake was improved by acidifying APP.

At Elliston, results were similar with Sloop barley to those with Krichauff wheat at Emerald Rise. There was no detrimental effect of acidification on the performance of APP. Micronutrients at Elliston were applied separate to the APP solution but still appeared to be effective. Zn uptake was improved by acidifying APP at this site also.

In future, we need to look closer at how much Zn and Mn can be combined with acidified APP and compare this with low rates of chelated Zn and Mn to identify the most cost effective mix.

Although the different types of fluid fertilisers generally produced similar wheat yields in these trials, the lower cost of phosphoric acid as a fluid P source meant that it was usually the only fluid fertiliser (including acidified APP where it was used in a mix with APP) which produced financial outcomes as good or better than granular P.

To compare the financial performance of fluid P fertilisers with granular we have assumed that a "typical" farmer in most of these districts is currently using 10 kg P/ha as granular fertiliser (for Elliston we assumed 12 kg P/ha). If the farmer had switched over to fluid fertilisers he could have achieved at least the same gross margin with a fluid fertiliser, based on their performances in these trials.

Low rates of applied P as acidified APP or phosphoric acid produced gross margins per hectare equal to and often much superior to granular in all of the trials summarised in this paper. The worst outcomes for the fluid fertilisers occurred with APP (because of its high cost) but it still only caused financial disasters at the two Penong sites and Miltaburra.

On the other hand the best financial outcomes for fluid fertilisers resulted in gross margins spectacularly higher than granular. For example, at Emerald Rise, 8 kg P/h as acidified APP resulted in a gross margin about $50/ha higher than granular and that was in a crop which only yielded just over 1 t/ha (although the price received was $228/t !!). At Elliston, in a Sloop barley crop yielding over 2 t/ha, acidified APP produced a gross margin about $40/ha higher than achieved by granular fertiliser.

These very crude financial comparisons of the performance of fluid fertilisers at six trials conducted in 2002 suggest that fluid fertilisers may be able to at least pay their way, and often provide impressive improvements in profitability, based solely on their impact on crop performance in the year of application. This may still under-rate their value, however, because there have been some hints already that fluid P fertilisers may have superior residual benefits to granular fertilisers. In addition, there is the very real prospect of substantially reducing the costs of fluid fertiliser mixes in the future. For example, some of the mixes used in the trials reported in this paper contained trace elements at a rate and in a form which cost up to $50/ha. More experience with the behaviour of trace elements in fluid fertiliser mixes are likely to reduce rates (and hence costs) of trace elements without sacrificing crop performance.

The fluid fertiliser team will be investigating the financial impact of fluid P fertilisers in a much more thorough way than used in this paper in the next few months and will include their entire database of trials and farmer experiences in the investigation.

Acknowledgments

We thank GRDC and the Fluid Fertilizer Foundation for their support, also Reg & Dot Brace & Sons, Tim & Tracey van Loon, Keith & Julie Tree, the Mudge family, Bill & Laura Oats and Garth & Maryanne Michelle for their valuable support. We would like to thank Agrichem and Pivot for their generous support. We also thank Wade Shepperd, Shane Doudle and Kay Brace for their excellent technical support.

GRDC Grains Research & Development Corporation

SARDI R&D SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

FLUID FERTILIZER FOUNDATION

Nutrition

Location
Emerald Rise
Closest town: Poochera
Cooperator: Reg, Nigel & Dion Brace

Rainfall
2002 Annual total: 198mm
2002 growing season: 168mm

Soil
Red, brown calcareous sandy loam
5.1% calcium carbonate
22 mg/kg Colwell P

Plot size
15m x 6 rows x 4 reps

Other factors
Dry period August-September

Suspension Fertilisers - An Alternative to Clear Fluids?

Bob Holloway, Alison Frischke and Dot Brace

SARDI, Minnipa Agricultural Centre

Key Messages

- **Suspensions perform better than APP on a grey calcareous soil at Yandra and similar to APP on a red brown calcareous soil at Emerald Rise and a grey calcareous soil at Streaky Bay.**
- **Suspensions are a thicker solution than clear fluid fertilisers but were not as difficult to apply as expected.**
- **Suspensions may be a cost-effective alternative to fluids in the future because they can be made in South Australia.**

Why do the trial?

Ammonium polyphosphate (APP) has been a solid performer in experiments comparing fluid and granular fertilisers but it is expensive. APP is a clear liquid but it is difficult to mix zinc and manganese sulphate with it, which are the cheapest sources of trace elements. To overcome this mixing problem we are trialing suspension fertilisers. Suspensions can be made relatively easily, and consist of a mixture of nutrients - virtually any combination is possible - to which water is added and then fine clay to keep the mixture in suspension. Suspensions are applied without filtration and are best dribbled out under the seed in a continuous stream.

EMERALD RISE

How was it done?

Method:

Plots were sown with Krichauff wheat on the 5th of June with all fertilisers placed below the seed. All plots received 10 kg N/ha and 10 kg P/ha (granular urea was used to balance N if required).

Treatments:

5 different suspension mixes, 1 clear fluid and 1 granular

Suspensions: 11:12 Pivot A; 10:13 Easy NP® Incitec; 16:17 Groflow® Agrichem; 7:7:0:S Slurry mix 2; 9:9:0:S Slurry mix 3

Fluid: 14:21 LMAP®

Granular: 10:22 MAP

Measurements:

Early dry matter production, grain yield, protein.

What happened?

Dry matter comparisons were made in August at late tillering. LMAP® produced 30% more dry weight of shoots than MAP. The suspension Groflow® performed well producing 31% more than MAP, as did Easy NP® which produced 24% more than MAP (see figure 1).

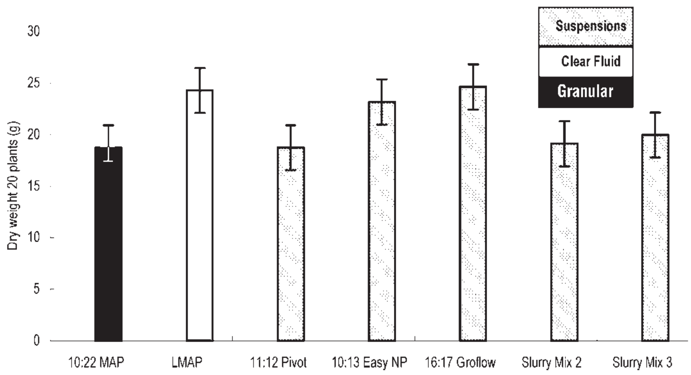


Fig.1: Response of shoot dry weight of Krichauff wheat to different fertilisers at Emerald Rise, August 2002 (vertical lines are the LSD at P=0.05).

At harvest, LMAP® yielded 1.66 t/ha compared with 1.31 t/ha with MAP, a difference of 26%. However, most of the suspensions also exceeded the yield of MAP plots - (% difference shown in brackets) Groflow® (19%), Pivot 11:12 (18%) and Easy NP® (14%). Slurry mix 2 and 3 are experimental suspensions made from dry ingredients, with water and clay added. Slurry 3 increased grain yield by 19% (figure 2).

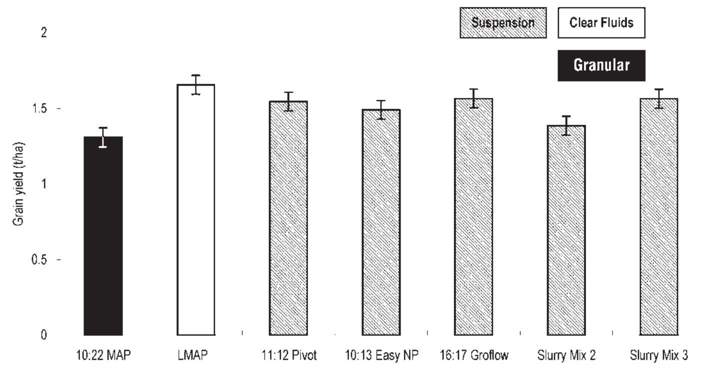


Fig.2: Response of grain yield of Krichauff wheat to different fertilisers at Emerald Rise, 2002 (vertical lines are the LSD at P=0.05).

YANDRA

How was it done?

Method:

Plots were sown with Krichauff wheat on the 11th of

Location
Yandra
Closest town: Streaky Bay
Cooperator: Ian & Gladys Morgan

Rainfall
2002 Annual total: 236mm
2002 growing season: 211mm

Soil
Grey highly calcareous sandy loam
67% calcium carbonate
44 mg/kg Colwell P

Plot size
15m x 6 rows x 4 reps

Other factors
Wildlife damage

June with all fertilisers placed below the seed. All plots received 10 kg N/ha and 10 kg P/ha (granular urea was used to balance N if required).

Treatments:

3 different suspension mixes, 1 clear fluid and 3 granular.

Suspensions: 11:12:Zn 1% Pivot; 10:13 Easy NP® Incitec; 16:17 Groflow® Agrichem.

Fluid: 14:21 LMAP®.

Granular: 10:22 MAP, 11:17:0:4.5 Cu 2% Incitec, Granulock 8:17:0:6.9 Zn 1% Incitec.

Measurements:

Early dry matter production, whole plant tissue analysis, grain yield, protein.

What happened?

Dry weight comparisons in figure 3 show that plants grown with 11:12:Zn1% suspension produced 56% more dry weight of shoots compared to MAP. The suspensions Groflow® and Easy NP® produced 47% and 27% more respectively than MAP. LMAP ® produced 30% more than MAP.

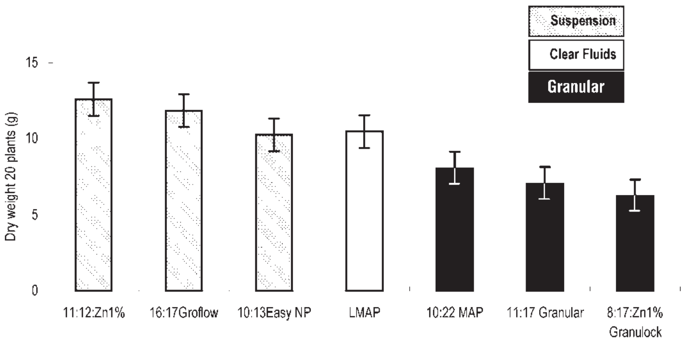


Figure 3: Response of shoot dry weight of Krichauff wheat to different fertilisers at Yandra, 2002 (vertical lines are the LSD at P=0.05).

The season was harsh at both Emerald Rise and Yandra. At harvest visible differences were still present at Yandra. In other experiments at other sites, early differences had disappeared by maturity. 11:12:Zn 1% yielded 37% more than MAP, Groflow® 33% and Easy NP® 21% (figure 4). LMAP® yields were not different from those of MAP.

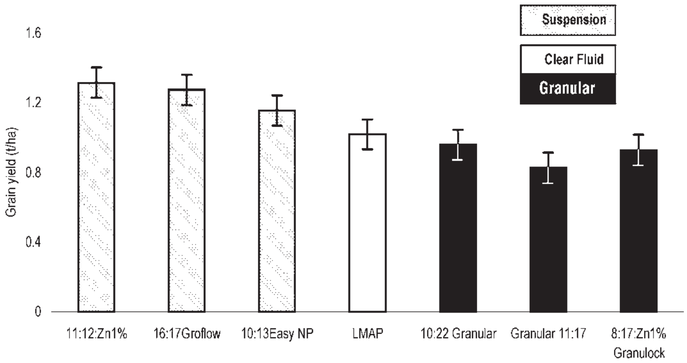


Fig.4: Response of grain yield of Krichauff wheat to different fertilisers at Yandra, 2002 (vertical lines are the LSD at P=0.05).

STREAKY BAY

Location
Streaky Bay
Closest town: Streaky Bay
Cooperator: P & N Wheaton

Rainfall
2002 growing season: 232 mm

Soil
Grey highly calcareous sandy loam
36% calcium carbonate
37 mg/kg Colwell P

Plot size
15 m x 1.5 m x 4 reps

Method:

Plots were sown with Krichauff wheat on the 4th of June 2002 with all fertilisers placed below the seed. All plots received 14 kg P/ha, 14 kg N/ha, 2 kg Zn/ha (granular urea was used to balance N if required).

Treatments:

5 different suspension mixes, 5 clear fluids and 4 granular.

Suspensions: 11:12 Zn 1% Pivot; 10:13 Easy NP® Incitec; 16:17 Groflow® Agrichem; 'Slurry mix 2' 1:7:7; 'Slurry mix 3' 9:9.

Fluids: APP 14:21 LMAP®, phosphoric acid; 0:25.6, tech grade MAP; 12:26, APP 14:21 LMAP® + zinc, manganese and copper chelates; 10:16 Maxiphos® SprayGro.

Granular: 18:20 DAP + urea; 18:20 DAP + zinc sulphate; 'Tooligie mix' 13:15 6% Zn Pivot; nil (urea only).

Measurements:

Early dry matter production, whole plant tissue analysis, grain yield, protein.

Nutrition

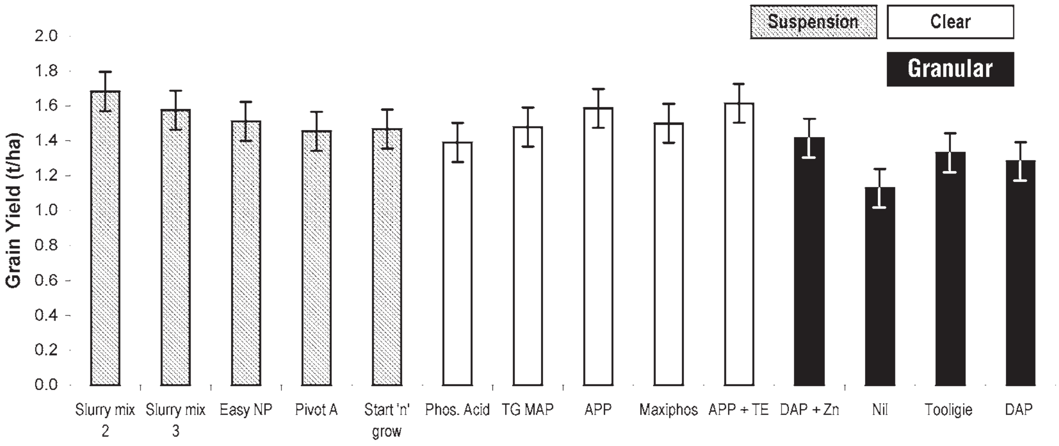


Fig.5: Response of grain yield of Krichauff wheat to different fertilisers at Streaky Bay, 2002 (vertical lines are the LSD at P=0.05).

What happened?

The two slurry mixes prepared by Bob Holloway (slurry mixes 2 and 3) and APP produced higher yields than DAP, a granulated fertiliser. All other fluid and suspension fertilisers resulted in yields intermediate to Slurry mix 2 and DAP. Amongst the trace element enriched fertilisers, only Slurry mix 2 produced higher yields than DAP+Zn.

There was a strong response to fertilisers with the nil treatment yielding 0.3-0.6 t/ha less than fluid or slurries, depending on the product used.

What does this mean?

At three sites on different calcareous soils, suspensions produced yields equal to or better than APP, and APP generally produced yields better than granular fertiliser.

The possibility that suspensions will have the same benefits as clear liquids is exciting, given the expectation that they should be significantly cheaper in terms of cost per unit of P. There may be some application difficulties compared with clear solutions but these should not be difficult to solve. Companies who have begun to develop suspension technology are encouraged to continue in this pursuit. The wide range of nutrients which can be combined in suspensions makes them a very versatile tool for farmers on calcareous soils where multiple nutrient deficiencies are frequent and widespread.

Acknowledgements

We thank GRDC, Dr Larry Murphy of the Fluid Fertilizer Foundation, Jim May of James May Technologies Texas, Agrichem, Pivot and Incitec for their generous support and advice. We also thank Reg & Dot Brace & Sons, Ian & Gladys Morgan and Philip and Nigel Wheaton for their strong support of our research & development program.

We also thank Wade Shepperd, Shane Doudle and Kay Brace for their excellent technical support.

GRDC Grains Research & Development Corporation

SARDI South Australian Research and Development Institute

Fluid Fertilizer Foundation

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Key to symbols

Fluid Phosphorus - Water Rates and Row Spacing

Brendan Frischke,

SARDI, Minnipa Agricultural Centre

Key Messages Box

- **Use minimum application rates of 120 L/ha to achieve full potential benefit of fluid P.**
- **Aim for at least 10 psi system pressure to avoid blockages and achieve uniform distribution across the machine.**

Why do the trial?

Much of the previous trial work on fluid phosphorus has been conducted with neat product diluted in water and applied at rates up to 400 L/ha, and in some instances higher. Limited trial work on water dilution rates has suggested that application rates above 120 L/ha perform better. But results have been variable, in 2000 at Miltaburra; there was no difference in grain yield for application rates between 65 L/ha (neat product) and 400 L/ha. However at Yandra in the same year, application rates below 120 L/ha yielded less. In a trial at Emerald Rise in 2001, yield increases were still evident by increasing water rates up to 480 L/ha (the highest rate in the trial).

Many farmers are applying low rates of P (4-6 kg/ha) to offset the currently high cost of fluid P. At 6 kg P/ha, the volume of product applied is 15 L/ha for phosphoric acid (without N) and 43 L/ha for ammonium polyphosphate. Farmers are applying fluid fertiliser solutions at volumes as low as practicable because adding more water reduces the area that can be sown before refilling and more water needs to be transported to the paddock. These low rates of application may be reducing the effectiveness of fluid P.

The aim of this research is to further evaluate the effect of water application rate on P efficiency and examine the effect of row spacing on water rates response.

How was it done?

Experiments were established at Yandra and Miltaburra on highly calcareous sandy soils. Krichauff wheat was sown at 60 kg/ha and at a depth of 2-4 cm at both sites.

Yandra

The effects of water rate and crop row spacing were investigated.

Fertiliser solutions were mixed using ammonium polyphosphate (APP), urea ammonium nitrate (UAN) and chelated zinc (EDTA Zn) to provide 7.5 kg P/ha, 15 kg N/ha and 1 kg Zn/ha. The fertiliser solution was applied at total volumes of 80, 160 or 320 L/ha. Plots were sown at row spacings of 150, 225 and 300 mm for all water rates. Seeding rate was kept at the same kg/ha for all row spacings. Fertiliser was applied approximately 2 cm directly beneath the seed row.

Miltaburra

The effects of water rate and P rate were investigated.

Two rates of P (4 kg P/ha or 8 kg P/ha) were applied to wheat as a fertiliser solution applied approximately 2 cm below the seed. The fertiliser solution was applied at total volumes of 60, 80, 100, 120, 140, 200, 280 or 400 L/ha. N and Zn were applied to all treatments at 10 kg N/ha and 0.8 kg Zn/ha. Fertiliser solutions were mixed from APP, UAN and EDTA Zn. All plots were sown at 185 mm row spacing.

What happened?

Yandra

Two water rate treatments, 80 & 320 L/ha at 150 mm row spacing, encountered problems at seeding and had to be abandoned for the rest of the trial. At 320 L/ha several line blockages were caused by fine dust unknowingly entering the tank during a dust storm prior to sowing. With the combination of narrow row spacing (150 mm) and low water rate (80 L/ha), distribution system pressure and fluid flow through the nozzles were very low. This allowed excessive plugging of the nozzle orifice by soil. This resulted in most of the fertiliser being placed in one or two rows (Figure 1).

Location
Yandra
Closest town: Streaky Bay
Co-operator: I & G Morgan

Rainfall
Actual annual total: 236 mm
Actual growing season: 211 mm

Yield
Potential: 2 t/ha

Paddock History
2001: Spray topped pasture

Soil
Grey highly calcareous sandy loam
67% Calcium carbonate
43 mg/kg Colwell P

Diseases
Some Rhizoctonia.

Plot size
Small Plots: 2 m x 15 m
Replicates - 4

Other factors
Native wildlife damage.

Location
Miltaburra
Closest town: Wirrulla
Co-operator: L & M Mudge

Rainfall
Average annual total: 306 mm
Average growing season: 235 mm
Actual annual total: 235 mm
Actual growing season: 191 mm

Yield
Potential: 1.6 t/ha

Paddock History
2001: Spray topped pasture

Soil
Grey highly calcareous sandy loam

Diseases
Rhizoctonia.

Plot size
Small Plot - 2 m x 15 m
Replicates - 3

Figure 1: The crop row on the right with increased growth in this photo received most of the fluid fertiliser, Yandra 2002

Dry matter cuts at mid tillering showed that increasing application rate to 320 L/ha produced the greatest early growth (Table 1). Wider row spacing increased early growth from 269 kg/ha at 225 mm to 313 kg/ha at 300 mm, an increase of 21%, regardless of application rate. Increasing application rate increased P uptake. P uptake was 50% higher at a rate of 320 L/ha compared to 80 L/ha. Row spacing had no effect on P uptake.

Table 1: Effect of output rate on growth of Krichauff wheat Yandra 2002 (values in table are averages of row spacings 225 mm and 300 mm).

Water Rate (L/ha)	Early Dry Matter (kg/ha)	P Uptake (kg/ha)	Head Density (heads/m^2)
80	246	0.43	121
160	269	0.55	148
320	343	0.65	137
LSD (P=0.05)	73	0.16	17

Visual observations throughout the season (beyond tillering) gave a strong indication that application rates had a strong effect and that row spacing also had an influence. At 150 mm row spacing it appeared that growth improved by increasing the application rate from 80 L/ha to 160 L/ha and again but to a lesser extent to 320 L/ha. At 225 and 300 mm row spacing the lowest application rate (80 L/ha) appeared to be inferior to 160 and 320 L/ha but there was no visual difference between higher water rates. However the penalty for low application rates did not appear to be as severe at 300 mm row spacing compared to 225 mm.

Unfortunately while the wheat plants were at soft dough stage, our lovely friends the Galah got hungry. Every plot was damaged and some had more than 90% of stems bitten off. To make matters worse, when the mad researcher started stomping around like a raging bull two minutes later, he found himself precariously hovering on one foot above a three foot brown snake. Bad day.

To try and salvage some information from the trial, stalk density was measured as an indicator of head density (Table 1). The highest water rate increased head density by 13% compared to the lowest water rate. Yield could not be predicted reliably because information collected about grain size and grains per head was considered unreliable.

Miltaburra

There were no consistent visual differences between water rates during early stages of crop growth. A lot of root disease was evident in the crop last season which caused severe patches and very uneven plots. Dry matter was not measured because of the crop variability and no apparent effects. Analysis of grain yield showed an interaction between P rate and the volume it was applied at. At high application rates there was no difference in grain yield between 4 and 8 kg P/ha. However, grain yield increased slightly at 8 kg P with low application rates whereas yield decreased slightly at 4 kg P with low application rates (Figure 2). Increasing P rate from 4 to 8 kg increased grain protein from 13.0% to 13.3%. However application rate had no effect on grain protein.

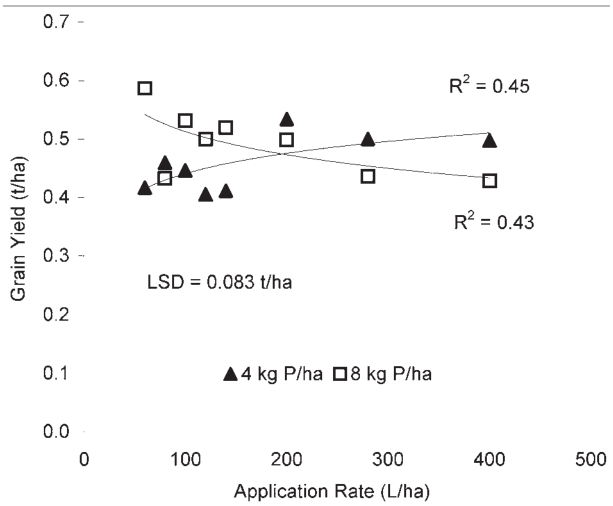

Figure 2: Yield response of wheat to fluid fertiliser application rate and P rate, Miltaburra 2002.

To summarise the last three years: There was no yield response to application rate at Miltaburra in 2000 but the lowest rate was visually poorer early in the season. At Yandra in 2000 application rates of 120 L/ha and above increased yield compared to neat product by 13%. At Emerald Rise in 2001 (high yielding year) yield was increased by 6% by increasing application rate from 120 to 480 L/ha. In 2002 at Miltaburra, at 8 kg P/ha rate yields were higher at lower application rates but at the lower P rate (4 kg P/ha) yields were approximately 13% less at application rates below 140 L/ha. At Yandra in 2002 growth with application rates below 160 L/ha were visibly lower.

What does this mean?

Water rate does influence the effectiveness of fluid P but the response varies between sites and years. In most years early growth is reduced at water rates below 100 L/ha. This hasn't always led to reduced yield in those years where rainfall was poor. Yield may have been affected if rainfall was higher. Therefore applying fluid P at a minimum of 120 L/ha would reduce the risk fluid applied P not performing to its full potential. The instances and magnitude of yield increases at higher water rates are not sufficient to suggest increasing water rates further would be an advantage at this stage. However more research is needed to unravel what causes yields to increase occasionally at very high water rates (above 200 L/ha) and what effect row spacings and P rate have on the impact of application rates.

Stepping back to granular; when applying granular fertiliser, granules are placed approximately 20 - 30 mm apart depending on factors such as granule size, row spacing and application rate. Other research has shown by applying the same fertiliser but at various particle sizes from conventional size down to almost powder, fertiliser efficiency is improved with smaller particles. This is partly attributed to the smaller particles being separated by less distance, to the extent that it's almost a continuous line for powder, improving the ability of plants to find nutrients. Similarly it was shown in the United States that if fluid P were applied as droplets rather than a continuous stream then plants might not utilise the fertiliser as efficiently.

From a practical point of view, as water rate is increased, the ability to maintain a continuous stream, even distribution between lines and reduce blockages is improved. Table 2 shows the fluid flow rate of each line for each given row spacing and water rate on a machine travelling at 10 km/hr (flow rate is proportional to speed). Every time flow through a tube or jet is doubled the backpressure is increased four fold. Nozzles and flow regulators (plate with an orifice in a spray nozzle body rather than a nozzle) with a small precision hole are very effective because they increase the system pressure compared to an open line with constant diameter, negating other small variable effects such as pressure drop along a line or unequal line lengths and because the holes are precise, the flow out of each is equal at uniform pressure. This is exactly the same as a boom spray but with a solid stream. Increased pressure also reduces (or eliminates if high enough) plugging of jets by soil. Increasing the water rate allows use of larger diameter jets (or orifice plate in other systems), which reduces blocks caused by small particles in the fertiliser solution. Problems caused by low flow and pressure was evident at Yandra in the row spacing trial at the lowest row spacing and water rate. The orifice size in this case was 0.8 mm and sowing speed 6 km/hr. Reducing the orifice size would risk more blockages from particles in the fertiliser solution; increasing water rate and ground speed in this case would be more reliable.

Using Table 2, the flow in litres per minute through each jet can be calculated from row spacing, water rate and speed. Table 3 shows an approximation of the pressure flow relationship for water through a selection of solid stream jets with different diameters. Using the result from Table 2, Table 3 can be used to estimate the system pressure for each orifice size. Choose a size that will gives at least 10 psi pressure for reliable results. Clear fluids like UAN or APP work fine with small holes provided filtration is adequate. However, when precipitates are likely (eg APP with trace elements) larger sized holes will reduce frustration of cleaning blocks during seeding, but might require a higher water rate to maintain pressure and avoid poor distribution.

Table 2: Flow rate in litres/minute per tine at selected row spacings and water rate and at 10 km/hr.

Row Spacing (mm)	Application Volume (L/ha)			
	80	100	120	320
150 (6")	0.20	0.25	0.30	0.80
185 (7")	0.25	0.31	0.37	0.99
225 (9")	0.30	0.38	0.45	1.20
300 (12")	0.40	0.5	0.60	1.60

Table 3: Approximate pressure (psi) required for a given fluid (water) flow and hole size. Note: doubling the output flow increases pressure four times, 1 bar = 100 kpa = 14.5 psi.

Orifice Diameter (mm)	Fluid Flow Rate (Litres/minute)*							
	0.1	0.2	0.4	0.6	0.8	1	1.2	1.6
0.84	1.2	4.9	19.7	44	79	123	178	316
0.99	0.7	2.8	11.2	25	45	70	101	179
1.2	0.3	1.2	5.0	11.2	20	31	45	79
1.5	0.1	0.5	1.8	4.1	7.3	11.4	16.4	29

**Flow pressure relationship is affected by specific gravity (SG) and fluid viscosity.*

Acknowledgments

This work is part of the GRDC funded project "Fluid fertilisers - the next step towards raising yield potentials" (CSO-231). Thankyou to Ian and Gladys Morgan and Leon, Marilyn, Carolyn and Darren Mudge for allowing access to their land for the purpose of conducting trials.

Location
Buckleboo
G Baldock

Av. Annual rainfall: 304 mm
2002 rainfall: 188 mm

Soils
sandy loams
Colwell P: 19-25 mg/kg
Calcium Carbonate: low

Plot size:
1.5 x 20 m

Location
Kalanbi
B Bergmann

Av. Annual rainfall: 275 mm
2002 rainfall: 176 mm

Soil
Sandy loam
Colwell P: 24 mg/kg
Calcium Carbonate: moderate

Plot size
1.5 x 13 m

Investigating the Potential of Fluid Fertilisers at Buckleboo and Kalanbi

Alison Frischke,

SARDI, Minnipa Agricultural Centre

Key Messages

- **Crops responded to the application of fluid fertiliser as well as, or better than, granular fertiliser at Buckleboo and Kalanbi when nitrogen deficiency was not a factor.**
- **Results from a variety of seasons need to be considered before drawing firm conclusions regarding the viability of using a fluid fertiliser system.**

Why do the trial?

When you begin to consider the use of fluid fertilisers in your farming operation, the ultimate question that pops immediately into your mind is 'will it work on my soils?'. Fluid fertilisers should work on all soil types provided that adequate nutrients are applied (may need additional foliar applications where there's a specific nutrient deficiency), and they are not leached out of the root zone. However, the big question is whether they work better than granular fertilisers. If there is a grain yield benefit in using fluid compared with granular fertiliser, the magnitude of this benefit will vary with soil type and season, and must be large enough to cover the cost of the more expensive fluid fertilisers.

These trials were established in response to farmer groups at Buckleboo and Kalanbi asking the above question, with the aim of measuring the grain yield response of wheat to the addition of phosphatic fertilisers applied in either granular or fluid form.

How was it done?

Trial details:

Experiments were sown into 3 different soil types within a single paddock at Buckleboo, typifying the grey, sandy and red soil types found within the district (refer to the article "Subsoil Nutrition Demonstration at Buckleboo" in the Soils Section for further details on soil types). At Kalanbi, a single trial was sown on a typical sandy loam site.

Treatments:

Fertilisers were applied to supply 12 kg P/ha, 11 kg N/ha, and 1 kg Zn/ha at both sites. In addition at Buckleboo, Cu and Mn were applied at 1kg/ha. At Buckleboo, granular fertiliser was applied as 13:15 6% manganese, urea 5% zinc, triple super phosphate and copper sulphate. Fluid fertiliser was applied as ammonium polyphosphate, urea ammonium nitrate, and zinc, copper and manganese chelates. The trial was sown with Krichauff wheat on 3rd June.

At Kalanbi, granular fertiliser was applied as di-ammonium phosphate and granular zinc sulphate. Fluid fertiliser was applied as ammonium polyphosphate, urea ammonium nitrate, and zinc chelate. The trial was sown with Krichauff wheat on 19th June.

What happened?

At ***Buckleboo,*** there were early dry matter responses to applied nutrients on all soil types. Grain yields responded to the applied nutrients on the grey and sandy soil types, but not on the red soil, despite the early dry matter differences. Fluid fertiliser enhanced early plant growth and improved grain yields compared to granular fertiliser on the grey soil type. On the red soil types fluids performed equally as well as granular fertiliser, while on the sand fell slightly behind, most likely due to leaching of nitrogen, which was evident as paler crops in fluid fertiliser treated plots.

Table 1: Dry Matter Production at Tillering and Grain Yield of Krichauff wheat at Buckleboo and Kalanbi, 2002.

Fertiliser	Buckleboo						Kalanbi	
	Grey		Sand		Red			
	Dry Matter (g/plant)	Grain Yield (t/ha)	Dry Matter (g/plant)	Grain Yield (t/ha)	Dry Matter (g/plant)	Grain Yield (t/ha)	Dry Matter (g/plant)	Grain Yield (t/ha)
Nil	0.32	0.40	0.59	0.65	0.74	0.48	0.55	0.78
Granular	0.44	0.50	0.98	0.92	1.01	0.47	0.62	0.82
Fluid	0.49	0.52	0.97	0.87	1.05	0.44	0.78	0.83
LSD (P=0.05)	0.03	0.02	0.21	0.05	0.11	ns	0.11	0.03

At *Kalanbi,* early dry matter and grain yields benefited from the addition of fertilisers. Fluid fertilisers enhanced early plant growth compared to those treated with granular fertiliser, however, final grain yields were similar.

What does this mean?

These results from the 2002 season should be treated with caution given that the season was a below average season for both trial sites. However, the data does indicate that when N deficiency is not a factor, fluid fertilisers will produce crops as good, or better than granular fertilisers on the soils tested.

From previous trial experiences we would expect that soils with significant levels of calcium carbonate, (>5% calcium carbonate) that can tie up phosphorus making it unavailable for plant uptake, would see yield improvements from applications of fluid fertiliser compared with granular fertiliser in most seasons.

Given that the response of soils to applications of fluid fertilisers varies with each season, and that they are more expensive, results from a variety of seasons need to be considered before drawing firm conclusions regarding the viability of using a fluid fertiliser system.

Acknowledgments

This work was funded by GRDC, and would not have been possible without the valuable assistance of Graham Baldock (Buckleboo), Brenton Bergmann (Kalanbi), Sam Doudle, Leigh Davis and Wade Shepperd (SARDI, Minnipa), and Brenton Growden and Terry Blacker (SARDI, Pt Lincoln).

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Key to symbols

Nutrition

Location
Mudamuckla
Closest town: Ceduna
Cooperator: Fluid P research team at MAC

Rainfall
Av. Annual total: 275 mm
Av. Growing season: 200 mm
Actual annual total: 210 mm
Actual growing season: 185 mm (decile 3)

Yield
Potential: 1.5 t/ha
Actual: up to 1.3 t/ha

Soil
Major soil type description: grey calcareous sandy loam

Plot size
Strips with commercial header

Other factors
See individual demonstrations

Fluid Fertilisers at Mudamuckla in 2002

Peter Kuhlmann,

"Mudabie" Mudamuckla, Upper Eyre Peninsula

Key Messages

- **Converting to fluid delivery system was not difficult and caused no problems during seeding program.**
- **Applying APP pre-seeding appeared to give satisfactory results and fits well into the system.**
- **Benefits not clear in all cropped areas of the farm, but overall pleased with the performance of fluids.**

Why do the trial?

To measure any benefits from using fluid P fertiliser, APP, at seeding time as well as putting the fertiliser out when working up. I have a no till seeding rig with Harrington points and a conventional machine with sweeps but only one fluid cart and transfer tanker. The expected residual benefits of fluid fertilisers should enable the fertiliser to be put out earlier while working up when timeliness is less critical. I used APP over my entire cropping area with the minimum till paddocks also having 30 kg/ha of DAP at seeding time.

In 2001/2002 I decided that the benefits of fluid fertilisers on my soil type outweighed the challenges of changing over my fertiliser operation. Having decided to convert to fluid fertilisers, I put a system in place so that I could seed my entire cropping programme in 2002 with fluid fertilisers. My criteria were to have an effective product which was "safe" to use and to create an efficient means of handling and distributing it.

I ended up spending slightly more dollars on fluid fertiliser /ha in 2002 compared to my previous rate of 50 kg/ha of 18:20. The cost of APP, the fluid product I chose to use, was 2.85 times more expensive than the granular products per unit of phosphorus.

My system for 2002 was made up of the following components -

Product:

Ammonium Poly Phosphate (APP) 14:20.7:0 in bulk

On farm storage:

27,000 litre molasses grade poly tanks

Transfer method:

17,000 litre stainless steel milk tanker

Fluid cart:

Burando Hill cart with 7,000 litre tank and ground drive John Blue pump

Distribution and metering:

Quick release spray type fittings with an orifice plate and garden sprayer nozzle at the boot.

How was it done?

The crops were sown in May with negligible grass control and enough rain to germinate most of the seed. June and July were above average rainfall and the crops established well despite some suffering from an N deficiency and yellow leaf spot.

The dry August and September trimmed back our yield potential. The deeper soil types yielded better than expected and the crops on the shallow soils produced very little grain.

Strips were marked at working up or at seeding time and were harvested separately using a yield monitor. Strips were not replicated but were at least 600 m long making them at least 0.7 ha in area.

What happened?

Paddock 42

1999	Barley	Barque	
2000	Barley	Barque	
2001	Pasture	Regenerated	
	• Glyphosate	4/9/01	600 mL/ha
	• Glyphosate	30/10/01	500 mL/ha
	• Ester	30/10/01	350 mL/ha
2002	Wheat	Yitpi	
	• 22 Jan	500 mL/ha MCPA 500 + 5 g/ha Ally	
	• 12 May	Worked up with sweeps (dry) + 15 L/ha APP (= 3 units P) in 100 L/ha	
	• 31 May	Sowed with sweeps and press wheels - 60 kg/ha Yitpi + 30 kg/ha 18:20	
	• 1 June	Sprayed 450 mL/ha Credit & Bonus + 24 g/ha Logran	

Trial strips:

At seeding there were 6 laps on the northern side with no fertiliser. The balance of the paddock had 30 kg/ha of 18:20.

Table 1: Grain yield of Yitpi wheat with different fertilisers at Mudamuckla, 2002: Paddock 42

	Working up			Seeding	Yield (t/ha)
	APP (L/ha)	Water (L/ha)	Zn (kg/ha)	18:20 (kg/ha)	
North side					
Lap 1	15	100	0.22	0	0.90 *
Lap 2	30	200	0.44	0	1.25
Lap 3	15	100	0.22	0	1.08 *
Lap 4	-	-	-	0	0.79
Lap 5	15	100	0.22	0	0.94 *
South side					
Lap 1	15	100	0.22	30	0.80 **
Lap 2	30	200	0.44	30	0.85
Lap 3	15	100	0.22	30	0.73 **
Lap 4	-	-	-	30	0.57
Lap 5	15	100	0.22	30	0.75 **

** or ** are the same treatments*

The nil P appeared a thin crop.

The higher rate of APP and water produced the highest yields and the crop was laying down more.

The 18:20 at seeding reduced the yield variation between the APP applications.

The North side of the paddock grew a better crop this year but the relative differences were similar on the Southern side.

Another similar trial was done but sandier soil and better grass control further into the paddock skewed the results. The yield variations also indicated that pre sowing fluid fertiliser was a realistic option.

Other trials and missed strips

Paddock 31

(Pasture 2001 includes 15 L/ha of APP at seeding)

No APP working up 1.26 t/ha

15 L/ha APP working up 1.28 t/ha

Seeding rate

58 kg/ha
1.60 t/ha

34 kg/ha
1.05 t/ha (more wind damage)

Paddock 17

(Stubble)

2nd lap alongside road, No P 0.94 t/ha

1st and 3rd laps, 20 L/ha APP at seeding 0.99 t/ha

No P was thinner with larger heads. The rest of the paddock was shorter and thicker.

Paddock 8

(Pasture in 2001, worked up, grassy)

2nd lap alongside driveway, No P 0.33 t/ha

3rd lap, 20 L/ha APP at seeding 0.55 t/ha

Paddock 10

(Pasture in 2001, fertile paddock, 20 L/ha APP at seeding)

1st lap - worked up 0.87 t/ha

2nd lap - no till 0.76 t/ha

3rd lap - no till - no APP 0.77 t/ha

4th lap - no till 0.67 t/ha

Comments

Placing the fluid below the seeding depth resulted in unacceptable damage to the tubing and nozzles in our stony environment. The nozzle is now protected inside the steel boot alongside the sowing hose.

Mixing zinc sulphate with APP forms a precipitate and requires good agitation to allow the APP to sequester the zinc and hence keep all the products in suspension. A fire fighting pump is required to achieve good agitation.

There were no ongoing problems with storage, filters, flow metering, pumps, calibration, blockages or handling issues.

What does this mean?

The liquid P (APP) gave a stronger plant establishment than normal and I would have expected a greater yield response if we had had a better spring.

The liquid P yield response was variable across the different paddocks with the more fertile paddocks being less responsive.

My own trials indicate that pre-seeding fertilising with fluid APP is a practical option which fits with the phosphorus mobilising ability of APP as Mike McLaughlin's research is suggesting.

The much higher price per unit of P of fluid fertilisers and the fact prices have not changed much in 2003 despite the growing volumes used is disappointing and is limiting the application rate and uptake of this technology.

Now I am set up for fluids the benefits to me are better plant establishment, more phosphorus available through its mobilising and residual benefits and potential yield increases.

Looking At Fluid Phosphorus - a Systems Approach

Neil Cordon[1] and Ian Creeper[2]

[1]SARDI, Minnipa Agricultural Centre, [2] formerly SARDI, Minnipa Agricultural Centre

Location
Closest Town: Wirrulla
Cooperator: Craig & Janette Rule
Group:Nunjikompita Ag Bureau

Rainfall
Av. Annual: 300mm
Av. Growing Season: 208mm
2002 total: 202mm
2002 Growing Season: 178mm

Yield
Potential (w): 1.4t/ha

Paddock History
2001: Medic
2000: Wheat
1999: Medic

Soil
Red Calcareous Sandy Loam

Plot Size
13m x 1.6m x 4 reps

Other Factors
Dry conditions at grain filling

Key Messages

- **In a wheat/pasture system the degree of response to fluid P depends on soil type.**

Why do the trial?

To investigate the effect of forms of P fertiliser on wheat yields, medic production and Pratylenchus neglectus levels in a wheat/pasture system.

Numerous studies have identified production limitations of medic and wheat on Upper Eyre Peninsula called 'medic decline' and 'sick wheat' syndromes. This trial is focusing on a wheat/medic rotation for three years to see if fluid P can positively influence both phases of the rotation.

How was it done?

Trial Details:

A phase of grass free medic was established over the trial site in 2001, with no fertiliser applied during that year.

In 2002 medic and wheat was sown with either no fertiliser, granular P or fluid P. The wheat variety was Yitpi, sown on 22nd May at 65 kg/ha under excellent soil moisture and seeding conditions.

Treatments:

Fertiliser applications consisted of 8 kg P/ha either as triple super or phosphoric acid compared to nil fertiliser.

Output rate for the fluid application was 120 L/ha and both fertilisers were applied in the seeding operation.

Measurements:

Grain yield, grain quality and P. neglectus levels.

What Happened?

Early in January 2002 the paddock was sprayed with Ally® at 5 g/ha, which inadvertently included the trial area. For this reason measurements of medic production were not done due to suspected herbicide damage to the medic even though there was a good germination.

There was no yield difference between the forms of P nutrition however they both yielded better than the nil fertiliser treatment (Table 1). No treatments had an effect on grain quality whilst data from P. neglectus monitoring was not available at the time of printing.

Table 1: Grain yield and grain quality of wheat at Wirrulla in 2002.

Treatment	Protein %	Screening %	Test Wt. kg/hectoL	Yield t/ha
Fluid P	14.4	1.9	82	0.78
Granular P	14.4	2.0	80	0.75
Nil	14.2	2.2	81	0.63
LSD ($P \leq 0.05$)	N/S	N/S	N/S	0.04

Yields were only 56% of the potential which may have been caused by the erratic rainfall patterns and not using starter nitrogen.

What does this mean?

This is the second year of a three year project so any trends or conclusions are limited and may become more obvious during 2003. In 2003 wheat will be seeded into plots with medic in 2002 and plots with wheat in 2002 will be seeded with medic. P fertilisers will be not be used in 2003 to test the residual impact of different P forms.

This initial data highlights the need to carefully consider soil type before adopting a change to phosphorus application in the fluid form. The site is considered to be mildly calcareous and is transitional between the red and grey country.

Acknowledgments

This Project was funded by the GRDC. We thank Wade Shepperd for his excellent technical assistance.

The benefit of nitrogen and phosphorus fertilisers for wheat production on grey calcareous soils

Jon Hancock,

SARDI, Minnipa Agricultural Centre

Location
Closest town: Miltaburra, Warramboo, Yandra
Cooperator: L&M Mudge, T&T VanLoon, I&G Morgan

Rainfall
Av. Annual total: M=305, Y=370
Av. Growing season: M=235, Y=298
Actual annual total: M=235, W=206, Y=243
Actual growing season: M= 191, W=153,Y=211

Yield
Potential: M=1.62, W=1.92, Y=2.01
Actual (best treatment): M=0.57, W=1.14, Y=0.68

Soil
Land System: Miltaburra - undulating coastal low hills and plains with deep grey highly calcareous sandy loams with calcrete outcrops.
Yandra - undulating calcrete plains with rises and mostly shallow soils over sheet calcrete.
Warramboo - Jumbled calcarous sand ridges over calcrete plains with some calcrete ridges.
Major soil type description: highly calcareous grey sandy loam

Plot size
15m x 1.4m

Key messages box

- **Fluid phosphorus fertilisers outperformed granular phosphorus fertilisers at all three sites.**
- **The full benefit of improved phosphorus nutrition with fluid phosphorus fertilisers could not be realised without the addition of nitrogen also at Miltaburra and Yandra.**
- **Nitrogen applications increased grain protein at each site.**

Why do the trial?

Applications of nitrogen fertiliser to wheat crops on Upper Eyre Peninsula have historically been low but recent work on improving the efficiency of phosphorus fertiliser may mean that the use of N fertiliser should be re-examined. Replicated field trials were established to determine crop responses to different rates and forms of nitrogen in conjunction with different forms of phosphorus fertiliser. This article follows on from the article in the 2001 EPFS Summary on page 93.

How was it done?

Wheat (cv. Yitpi) was sown into field trials at Miltaburra, Warramboo and Yandra on May 31, May 29 and June 12 respectively. Seed was delivered at 62 kg/ha and fluid fertilisers were delivered at 240 L/ha. Three rates of nitrogen, as urea (0, 15 and 30 kg N/ha) were applied in either granular or fluid form. Two rates of phosphorus (0 or 15 kg P/ha) were also applied in either granular (triple superphosphate 20% P) or fluid (phosphoric acid based, 25.6% P w/w) form. A trace element mix containing zinc sulphate, copper sulphate and manganese sulphate at 1.5, 1.0 and 3.2 kg/ha of the trace element respectively was also applied as a fluid. Fertilisers were applied beneath the seed except for the granular fertilisers at Miltaburra, which were applied with the seed. Soil samples were taken prior to sowing to determine the amount of nitrogen available in the soil. Plant samples were collected at tillering, anthesis and maturity for dry matter measurements. Plots were harvested at maturity and grain samples were retained to measure grain protein and screenings. Gross margins were calculated using actual prices and the current Golden Rewards payment system.

What happened?

Miltaburra

Approximately 69 kg N/ha was available in the top 40cm at sowing time. The granular nitrogen treatments restricted emergence by almost 50%, subsequently restricting crop growth throughout the season. Until anthesis, the addition of fluid nitrogen increased dry matter production only when applied with 15 kg/ha of fluid phosphorus and by maturity only when applied with 15 kg/ha of fluid or granular phosphorus. Maximum grain yield (0.57 t/ha) was achieved when 15 kg/ha of fluid nitrogen was applied with 15 kg/ha of fluid phosphorus (Table 1). In the absence of adequate P nutrition, nitrogen applications actually caused yield to decline. Nitrogen applications increased grain protein levels across all phosphorus treatments (Table 2). All fertiliser combinations except for 15 kg/ha of fluid phosphorus applied with 15 kg/ha of fluid nitrogen were uneconomic (Table 3).

Table 1: Influence of phosphorus and nitrogen on grain yield (t/ha) at Miltaburra (lsd = 0.04, P = 0.05)

Nitrogen Treatment (kg/ha)	No Phosphorus	Granular Phosphorus	Fluid Phosphorus
Nil	0.33	0.37	0.38
15 Fluid	0.32	0.39	0.57
30 Fluid	0.20	0.34	0.50
15 Granular	0.27	0.34	0.44
30 Granular	0.21	0.24	0.37

Table 2: Influence of nitrogen on grain protein (%) at Miltaburra (lsd = 0.1, P = 0.05)

Nitrogen Treatment (kg/ha)	Nitrogen Treatment	Grain Protein (%)
Nil	Nil	12.4
15 Fluid	15 kg/ha Fluid	12.8
30 Fluid	30 kg/ha Fluid	13.1
15 Granular	15 kg/ha Granular	12.8
30 Granular	30 kg/ha Granular	12.8

Table 3: Influence of phosphorus and nitrogen on gross margin ($/ha) at Miltaburra (lsd = 10)

Nitrogen Treatment (kg/ha)	No Phosphorus	Granular Phosphorus	Fluid Phosphorus
Nil	17	-1	-15
15 Fluid	8	-3	22
30 Fluid	-34	-26	-2
15 Granular	-5	-17	-10
30 Granular	-32	-53	-39

Warramboo

Approximately 48 kg N/ha was available in the top 40cm at sowing time. Crop growth and grain yield was increased by phosphorus, with fluid phosphorus treatments outperforming granular phosphorus (Table 4). At maturity, the addition of nitrogen apart from 30 kg N/ha granular had increased crop growth by an average of 14% but this did not translate into any yield benefit. Grain protein was increased by 0.3% when granular phosphorus was applied but was unaffected by fluid phosphorus applications. The addition of nitrogen also increased grain protein levels (Table 5). The increases in return associated with improved nutrition were outweighed by increases in cost and consequently, gross margin return was the same for all treatments.

Table 4: Influence of phosphorus on dry matter production and grain yield (t/ha) at Warramboo

	No Phosphorus	Granular Phosphorus	Fluid Phosphorus	LSD
DM at Tillering	0.21	0.27	0.36	0.03
DM at Anthesis	1.47	1.57	1.80	0.17
DM at Maturity	1.93	2.02	2.29	0.18
Grain Yield	0.96	0.98	1.14	0.01

Table 5: Influence of nitrogen on dry matter production (kg/ha) and grain protein (%) at Warramboo

	Nil	15 kg/ha Fluid	30 kg/ha Fluid	15 kg/ha Granular	30 kg/ha Granular	LSD
DM at Maturity	1.89	2.11	2.15	2.20	2.05	0.21
Grain Protein	11.4	12.2	12.4	12.1	12.6	0.4

Yandra

Approximately 39 kg N/ha was available in the top 40cm at sowing time. Applications of nitrogen and phosphorus increased crop growth throughout the season and were reflected in final grain yield (Table 6). In the absence of phosphorus, nitrogen applications did not affect crop growth at any stage throughout the season, however improvements to crop growth as a result of improved phosphorus nutrition were magnified when nitrogen was applied also. Additions of nitrogen fertiliser only resulted in a grain yield response when applied with fluid phosphorus fertiliser. Grain protein levels were increased by the addition of nitrogen fertiliser, particularly when applied with fluid phosphorus fertiliser (Table 7). The overall gross margin returns were low due to the poor yields, however, the application of both phosphorus and nitrogen (except for 30 kg/ha granular) was positive and was better than when fluid phosphorus was applied on its own (Table 8).

Table 6: Influence of phosphorus and nitrogen on grain yield (t/ha) at Yandra (lsd = 0.13, P = 0.05)

Nitrogen Treatment (kg/ha)	No Phosphorus	Granular Phosphorus	Fluid Phosphorus
Nil	0.23	0.40	0.37
15 Fluid	0.28	0.41	0.61
30 Fluid	0.23	0.41	0.68
15 Granular	0.27	0.43	0.56
30 Granular	0.26	0.39	0.50

Table 7: Influence of phosphorus and nitrogen on the grain protein (%) at Yandra (lsd = 0.4, P = 0.05)

Nitrogen Treatment (kg/ha)	No Phosphorus	Granular Phosphorus	Fluid Phosphorus
Nil	10.5	10.3	9.9
15 Fluid	11.0	10.8	10.4
30 Fluid	11.0	11.8	11.1
15 Granular	11.3	11.0	10.6
30 Granular	11.6	12.0	11.6

Table 8: Influence of phosphorus and nitrogen on gross margin ($/ha) at Yandra (lsd = 30, P = 0.05).

Nitrogen Treatment (kg/ha)	No Phosphorus	Granular Phosphorus	Fluid Phosphorus
Nil	-7	-1	-29
15 Fluid	-7	-8	19
30 Fluid	-30	-16	30
15 Granular	-8	-3	9
30 Granular	-21	-21	-13

What does this mean?

At all sites, crop growth and grain yield increased as a result of improved phosphorus nutrition. The application of 15 kg P/ha was clearly better than when no fertiliser was applied and also better when applied as a fluid than when applied in granular form. At Warramboo, the addition of nitrogen had little effect, however at Miltaburra and Yandra, the full benefit of improved phosphorus nutrition through fluid phosphorus fertiliser in increasing early vigour, crop growth and grain yield could not be realised without the addition of nitrogen at rates higher than those used by most farmers in those districts. Whilst gross margin returns tended to be low in a poor season, the application of 15 kg/ha of fluid phosphorus fertiliser in conjunction with 15 kg/ha of fluid nitrogen fertiliser at Miltaburra or 30 kg/ha of fluid nitrogen at Yandra still had the highest returns.

Acknowledgements

I would like to thank Annie McNeill, Bob Holloway and Glenn McDonald for their assistance throughout the year. I would also like to thank Leon, Marilyn, Carolyn and Darren Mudge, Ian and Gladys Morgan and Tim and Tracy VanLoon for the use of their land for trials and staff of Minnipa Agricultural Centre, particularly Willie Shoobridge for technical assistance.

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Key to symbols

Late nitrogen applications to wheat on grey calcareous soils

Jon Hancock

SARDI, Minnipa Agricultural Centre

Location
Closest towns: Miltaburra, Warramboo, Yandra
Cooperators: L&M Mudge, T&T VanLoon, I&G Morgan

Rainfall
Av. Annual total: M=305, Y=370
Av. Growing season: M=235, Y=298
Actual annual total: M=235, W=206, Y=243
Actual growing season: M= 191, W=153,Y=211

Yield
Potential: M=1.62, W=1.92, Y=2.01
Actual (best treatment): M=0.57, W=1.14, Y=0.68

Soil
Land System: Miltaburra - undulating coastal low hills and plains with deep grey highly calcareous sandy loams with calcrete outcrops.
Yandra - undulating calcrete plains with rises and mostly shallow soils over sheet calcrete.
Warramboo - Jumbled calcarous sand ridges over calcrete plains with some calcrete ridges.
Major soil type description: highly calcareous grey sandy loam

Plot size
15m x 1.4

Key Messages

- **Grain yield was increased with nitrogen applications at Miltaburra and Yandra, but was unaffected at Warramboo.**
- **Grain protein was increased with nitrogen applications at each of these sites.**
- **Stream bar applications of nitrogen post seeding were no more effective than nitrogen applied at sowing under very dry and low yielding conditions.**

Why do the trial?

Applications of nitrogen (N) fertiliser to wheat crops on Upper Eyre Peninsula have been restricted because of concern that increased growth early in the season may reduce grain fill and cause haying off as the increased water use depletes soil moisture reserves by the end of the season. The aim of the trials was to assess whether plant responses to nitrogen can be improved when N applications are delayed.

How was it done?

Wheat (cv. Yitpi) was treated with BSN 10® and sown at 62 kg/ha in trials with a fully randomised block design and 4 replicates at Miltaburra, Warramboo and Yandra on May 31, May 29 and June 12 respectively. Fluid P (phosphoric acid based, 25.6% P w/w) was applied at 15 kg P/ha and delivered as a stream beneath the seed. A trace element mix containing 1.5 kg Zinc/ha, 1.0 kg Copper/ha and 3.2 kg Manganese/ha was also applied in the same stream at Miltaburra or in separate streams at Warramboo and Yandra. All fluids were applied at 240 L/ha. N applications amounting to 15 or 30 kg/ha were applied at four different crop growth stages - sowing, tillering, stem elongation and anthesis.

Nitrogen applications to some treatments were split and half of the nitrogen was applied at sowing with the remainder applied at either tillering, stem elongation or anthesis. In an additional treatment, a quarter of the nitrogen was applied at each of the four stages. Granular urea was used as the N source at sowing but UAN solution applied through stream bars was used for all of the in-crop N applications. The stream bars delivered 250 L/ha. Soil samples were taken prior to sowing to determine the amount of nitrogen available in the soil. Plots were harvested at maturity and grain samples were retained to measure grain protein and screenings.

What Happened?

At seeding time, approximately 54, 50 and 37 kg N/ha was available in the top 40cm at Miltaburra, Warramboo and Yandra respectively. The rainfall received following the in-crop nitrogen applications is shown in table 1.

Table 1: Rainfall (mm) received during the next two days and week after late N applications at Miltaburra, Warramboo and Yandra

Stage of late N application	Miltaburra		Warramboo		Yandra	
	2 days	1 week	2 days	1 week	2 days	1 week
Late Tillering	0	0.5	1.8	4.3	0	0
Stem Elonation	9.5	12.5	0	4.6	8	8.6
Anthesis	0	2	1	3	1	2

The application of nitrogen benefited grain yield at Miltaburra and Yandra, however in-crop nitrogen applications offered no advantage than when all of the nitrogen was applied at seeding time (Table 2). At Warramboo, grain yield was unaffected by the addition of nitrogen and averaged 1.06 t/ha.

At all sites, grain protein was increased through nitrogen applications, although it was generally no better with in-crop nitrogen applications than sowing applications (Table 3). At Miltaburra, grain protein was only increased by the rate of nitrogen and was 12.3, 12.7 and 12.9% for the application of 0, 15 and 30 kg N/ha respectively.

Table 2: Yield (t/ha) at Miltaburra and Yandra.

N Rate	Timing	Miltaburra	Yandra
0		0.41	0.43
15	Sowing	0.48	0.64
15	Late Tillering	0.44	0.48
15	Stem Elongation	0.43	0.44
15	Anthesis	0.35	0.44
15	Sowing and Late Tillering	0.44	0.52
15	Sowing and Stem Elongation	0.47	0.61
15	Sowing and Anthesis	0.37	0.56
15	All*	0.47	0.56
30	Sowing	0.37	0.70
30	Late Tillering	0.41	0.43
30	Stem Elongation	0.44	0.48
30	Anthesis	0.42	0.40
30	Sowing and Late Tillering	0.45	0.68
30	Sowing and Stem Elongation	0.51	0.67
30	Sowing and Anthesis	0.48	0.74
30	All*	0.46	0.58
LSD		0.08	0.07

**All = equal split between sowing, late tillering, stem elongation and anthesis.*

Table 3: Protein (%) at Miltaburra and Yandra.

N Rate	Timing	Warramboo	Yandra
0		11.7	9.6
15	Sowing	12.2	10.0
15	Late Tillering	12.1	10.4
15	Stem Elongation	11.9	10.2
15	Anthesis	11.8	9.7
15	Sowing and Late Tillering	11.8	10.0
15	Sowing and Stem Elongation	12.3	10.0
15	Sowing and Anthesis	12.0	9.7
15	All*	12.2	9.9
30	Sowing	12.7	10.8
30	Late Tillering	12.1	10.7
30	Stem Elongation	12.3	10.4
30	Anthesis	11.4	9.7
30	Sowing and Late Tillering	12.6	10.7
30	Sowing and Stem Elongation	12.6	10.6
30	Sowing and Anthesis	12.5	10.6
30	All*	12.3	10.2
LSD		0.5	0.3

**All = equal split between sowing, late tillering, stem elongation and anthesis*

What does this mean?

Despite using stream bar applicators and UAN as the nitrogen source, a technique considered to be one of the least risky for applying nitrogen in-crop, none of the late nitrogen applications offered any advantages over the application of nitrogen at sowing time. Streams of nitrogen fertiliser solution applied through stream bars contact only a small proportion of the leaf and the relatively large droplets tend to roll of, reducing the risk of leaf burn. The concentrated bands of nitrogen which end up along the soil surface are subject to loss through volatilisation until it is moved into the soil with rainfall, although it is less prone to loss than a spray equivalent and the UAN is less prone to loss than urea.

Post sowing nitrogen applications have benefited yields and protein in other environments, however the dry conditions at these sites last year may have limited the response. Although most of the applications were followed by some rain, as this method of getting nitrogen into plants relies upon root uptake, the nitrogen must be leached into the rooting zone with rainfall and the quantity of rain received may not have been great enough to do this. Through putting nitrogen out late, nitrogen rates can be better tailored to the season, however their role in this environment requires further evaluation over a range of seasons.

Acknowledgements

I would like to thank Annie McNeill, Bob Holloway and Glenn McDonald for their assistance throughout the year. I would also like to thank Leon, Marilyn, Carolyn and Darren Mudge, Ian and Gladys Morgan and Tim and Tracy VanLoon for the use of their land for trials and staff of Minnipa Agricultural Centre, particularly Willie Shoobridge for technical assistance.

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Late Nitrogen Applications at Wharminda

Jon Hancock

SARDI, Minnipa Agricultural Centre

Location
Closest town: Wharminda
Cooperator: John Masters
Group: Wharminda Ag Bureau

Rainfall
Av. Annual total: 272 mm
Av. Growing season: 199 mm
Actual annual total: 209 mm
Actual growing season: 141 mm

Yield
Potential: 0.62 t/ha
Actual: 1.3 t/ha

Paddock History
2002: Frame wheat
2001: Grass free, medic dominant pasture
2000: Schooner barley
1999: Excalibur wheat

Soil
Land System: Dune swale
Major soil type description: 30-40 cm siliceous sand over sodic clay

Diseases
Some rhizoctonia and crown rot

Plot size
18m * 1.1m

Other factors
Only 10mm in Sept and 14.5 mm in Oct set crop back severely, when it was starting to take off and demand moisture.

Key messages box

- **Applications of nitrogen did not increase grain yield or protein.**
- **The 60 kg N/ha required for crop growth was met by soil reserves.**

Why do the trial?

In past years, nitrogen has been considered to be one of the main nutrients responsible for increased grain yields when nutrients have been placed throughout the sandy A horizon of duplex soils at Wharminda. This trial was established to assess alternative approaches to applying nitrogen in-crop by comparing fertiliser sources, application techniques and application timing.

How was it done?

A trial was established at Wharminda where approximately 20 cm of sand overlays clay. The trial was sown to wheat (cv Yitpi) on June 13. Fluid fertiliser solutions, delivered at 256 L/Ha were applied beneath the seed and contained P, S, Cu, Mn and Zn applied at rates of 20, 4.3, 2, 3 and 3 kg/ha respectively. A total of 40 kg N/ha was applied to all treatments except for the control. This was either applied at sowing or equally split between sowing and a late application at stem elongation (4th September) and/or anthesis (1st October). The nitrogen applied at sowing was sourced from urea and was dissolved within the initial fluid fertiliser solutions. The late applications were sourced from either Urea or Urea Ammonium Nitrate and were either broadcast in their granular form or applied as a fluid through stream bars or normal spray nozzles. The stream bars and spray nozzles delivered 250 L/Ha. Soil samples were taken prior to sowing to determine the amount of nitrogen available in the soil. Plots were harvested at maturity and grain samples were retained to measure grain protein and screenings.

What happened?

Approximately 78 kg N/ha was available in the top 60cm. Rain didn't fall for 12 days after nitrogen was applied at stem elongation, however 10mm of rain fell the day after the anthesis applications to move the nitrogen into the soil. Grain yield was reduced when 40 kg N/ha was applied at seeding, but was unaffected by any other treatment (Table 1). Grain protein levels averaged 13.8% and were not affected by any treatment.

Table 1: Impact of nitrogen on grain yield

Nitrogen Treatment	Grain Yield
None	1.30
20 kg N/ha at seeding	1.28
20 kg N/ha at seeding and 20 kg N/ha in-crop	1.28
40 kg N/ha at seeding	1.10
LSD	0.1

What does this mean?

The application of nitrogen, regardless of how it was put on did not increase grain yield or protein in the 2002 season. One of the advantages of delaying nitrogen applications is that rates can be better tailored according to how the season is shaping up. Last year, with below average growing season rainfall, the total crop requirement for nitrogen was approximately 60 kg N/ha. This was met by nitrogen reserves within the soil and additional supplementation through fertiliser was not required.

Acknowledgements

I would like to thank Annie McNeill, Bob Holloway and Glenn McDonald for their assistance throughout the year. I would also like to thank John Masters for providing the trial site and spraying the trial, Terry Blacker and Brenton Growden for sowing the trial and Penny Day, Wade Shepperd and Willie Shoobridge for technical assistance.

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Extra N on wheat had little impact in the Cleve Hills but what have we learnt from elsewhere ?

Nigel Wilhelm and Brenton Growden

SARDI, Minnipa Agricultural Centre and Port Lincoln

Location
Cleve Hills
Mark & Andrea Hannemann
Crossville Ag Bureau

Rainfall
Av Annual : 464 mm
Av G.S.R. : 351 mm
2002 total : 316 mm
2002 G.S.R.: 238 mm

Potential Yield
2.56 tha (wheat)

Paddock History
2001 : Pasture
2000 : Feed oats (Wallaroo)
1999 : Janz

Soil Type
Loam over clay, pH 6.5 - 8.5

Plot Size
1.8 m x 25 m x 4 reps

Other Factors
Dry finish

Key Messages

- **Low yielding crop had little demand for extra N and differences between techniques could not be discerned.**
- **Previous experiences have shown that flowering N can improve grain quality but it is only profitable in heavy crops.**
- **Foliar applied N is usually not as effective as broadcast granular urea and is much more expensive.**
- **The type of N rarely makes a difference but the rate of N almost always does.**

Why do the trial?

This trial was conducted to compare the effects of different N fertiliser options on grain quality of wheat. It is part of a wider program which is supported by the CRC for Value Added Wheat to investigate the feasibility of improving wheat quality with late (flowering) applications of N and by choosing appropriate varieties.

The aims of this program are complementary to the needs of farmers in the Cleve hills who are having a lot of trouble delivering high protein wheat to the silo and who are keen to know if they can change their N fertiliser management to solve this problem. Given that applying foliar N has also been increasingly popular in the area over the last few years, they were also keen to see this technique compared against alternatives under the same conditions. There is also a suspicion that trace element deficiencies may be preventing their wheat crops from responding to higher applications of N, so treatments to test this theory were included.

How was it done?

Five wheat varieties were seeded on 5 June @ 86 kg/ha in a pasture paddock in the Cleve hills which had been pre-drilled with 23 kg N/ha. All plots received a further 41 kg N/ha at seeding (18 kg N/ha with the seed and 23 kg/ha banded below the seed row). A set of all five varieties received no further N for the season while a second set received an additional 26 kg N/ha as broadcast urea at late tillering and 16 kg N/ha as broadcast urea at early dough stage.

Wheat varieties tested:

Yitpi	Hard
Kukri	Hard
Westonia	APW
Camm	APW
Krichauff	ASW

A further ten treatments were conducted with Yitpi wheat to test the impact of trace elements and different rates, timings and application techniques of N on wheat quality. See table 1 for details of all 20 treatments; tillering N was applied 2 days prior to 11 mm of rain but only 1.5 mm of rain fell the day after early dough stage applications and then it was dry for a further 24 days with no further effective rain until after maturity.

The main focus of these treatments was on grain quality so a high rate of seeding N was used to avoid yield effects confounding with quality.

Grain yield, protein and screenings were measured at maturity.

What happened?

Despite the dry year (less than 70% of average growing season rainfall) and high rates of N at and prior to seeding, grain yield increased slightly with extra N during the season. The yield of all varieties increased by 0.15 t/ha, or 7%, with extra N at tillering and dough stage and reached levels around the potential. Varietal performance in this trial supports the strength of local wheat breeding programs with Krichauff, Yitpi and Kukri producing the best yields and good protein levels.

Protein levels were only just sufficient for ASW and APW grades despite relatively low yields and the use of at least 64 kg N/ha. Extra N at tillering and dough stage had increased grain proteins by about 0.6%, regardless of the variety. Krichauff produced the highest protein levels (as well as yield) while Yitpi had the lowest proteins. The hard wheat Yitpi performed very well with yields the same as Krichauff, reasonable proteins and very low screenings.

Table1: Effect of N rates and application options on performance of wheat in the Cleve hills, 2002.

Variety	Pre-drilled + Seeding N (kg/ha)	Broadcast N at tillering (kg/ha)	N at early dough stage (kg/ha)	Trace Elements at seeding	Yield (t/ha)	Protein (%)	Screenings (%)
Yitpi	64	0	0	Yes	2.49	9.5	3.2
Kukri	64	0	0	Yes	2.44	10.6	0.7
Westonia	64	0	0	Yes	2.26	10.2	2.0
Camm	64	0	0	Yes	2.44	10.5	1.7
Krichauff	64	0	0	Yes	2.48	10.7	0.9
Yitpi	64	26	16 urea b'cast	Yes	2.64	10.6	2.2
Kukri	64	26	16 urea b'cast	Yes	2.55	10.8	0.8
Westonia	64	26	16 urea b'cast	Yes	2.44	10.9	1.6
Camm	64	26	16 urea b'cast	Yes	2.53	11.1	1.6
Krichauff	64	26	16 urea b'cast	Yes	2.61	11.5	0.7
Yitpi	64	26	16 urea b'cast	No	2.62	10.1	2.7
Yitpi	64	26	16 urea b'cast	No but foliar TEs	2.72	10.8	2.2
Yitpi	64	26	16 foliar UAN	Yes	2.68	10.7	2.7
Yitpi	64	26	16 foliar urea	Yes	2.46	10.6	2.5
Yitpi	64	26	16 SB UAN[1]	Yes	2.54	10.2	2.1
Yitpi	64	26	16 SB urea[1]	Yes	2.39	10.5	2.8
Yitpi	64	26	0	Yes	2.68	10.3	2.3
Yitpi	64	26 Foliar	0	Yes	2.51	10.4	2.9
Yitpi	64	13	0	Yes	2.57	10.1	2.6
Yitpi	87	52	0	Yes	2.83	11.3	2.0
LSD (P=0.05)					0.26	0.7	0.6

[1] *SB - N applied with stream bar fittings on the boom spray unit.*

The late applications of N appeared to have had no impact on grain quality in this trial because proteins and screenings were similar in the treatment where only tillering N at 26 kg/ha was applied compared to all the others which received the same rate of N at tillering but also extra N at early dough stage. We have found in trials elsewhere that in low yielding crops under dry conditions, late applications of N have had little effect. In this trial no effective rain fell after the N applications at early dough stage.

Since late applications of N do not seem to have changed grain quality we can draw no conclusions about the relative effectiveness of the various techniques, sources of N and rates used. However, a high rate of additional N at tillering resulted in the highest yield in the trial as well the highest protein and lowest screenings for Yitpi. This matches with other similar trials we have conducted which have shown that while late N can improve wheat quality, early applications of N return the best profits for money spent on N. Tillering N applications were timed (luckily !) 2 days prior to a decent rain which is an ideal situation for this technique.

Growing Yitpi without trace elements supplied in the fertiliser did not appear to affect wheat growth or grain quality.

What does this mean?

The dry seasonal conditions experienced last year resulted in relatively low yields in this trial and would have reduced the demand for N by the crop and hence the impact of extra and late N treatments. Under these conditions it was not possible to identify differences between the types, application techniques and rates of N in their impact on wheat quality. Protein levels were quite high compared to the more common experience in the district in previous years of 6-8%.

As mentioned in the background, this trial was part of a large program looking at wheat quality and N management. In the large program many trials have now been conducted in reliable districts over the last three years, with most sites having had had soft finishes and high yields (2 to more than 6 t/ha). In this program most attention has been on durum until last year when several bread wheat varieties were included at each site. Under these high yielding conditions (greater than 3 t/ha) the following patterns have emerged:

- Flowering N does work. Protein increases from 0-4% have been recorded with 16-32 kg N/ha, applied as a foliar spray or as broadcast urea.
- Flowering N is not very profitable so should only be seen as a “rescue” or insurance option for high yielding crops.
- Seeding N has given best dollar returns compared to flowering N.
- Timing at flowering is not critical but perhaps early is best (pre flowering).
- Foliar applications of N have given disappointing results - unreliable and not as beneficial. They can burn crops but usually only aesthetic damage is caused.
- Foliar applications have not been the salvation for

tough conditions we had been led to believe.

- N source does not seem to be important - kg N/ha is.
- Urea is an effective source of N and is the cheapest.
- Even broadcast urea at flowering has often done a good job (in soft finishes).
- Camm is an excellent user of extra N (converts it into extra yield) under good growing conditions.
- Kukri will get more N into grain under the same circumstances (and not because of low yields).
- We have seen no reliable advantage with "additives" such as agrotain or humic acid.

The tough growing conditions of 2002 highlighted that while flowering N applications will boost the grain quality of wheat, it is only under high yielding conditions that the approach is financially attractive.

Acknowledgements

Many thanks to the Hanneman family for providing the trial site, to the Cleve Hills farmers for their interest and assistance with designing the trial and to Tear-arse Blacker for his stalwart technical assistance and record keeping.

Financial support from the CRC for Value Added Wheat made this trial possible.

SARDI

SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

GRDC Grains Research & Development Corporation

WHEAT CRC

Selenium-enriched-Wheat may prevent CANCER !

Graham Lyons[1], Dr Bob Holloway[2], Dot Brace[2], Dr James Stangoulis[1] and Prof Robin Graham[1]

[1] Adelaide University, Dept Plant Sciences, [2] SARDI, Minnipa Agricultural Centre

Location
Minnipa Agricultural Centre
Closest town: Minnipa
Cooperator: Bob Holloway and Dot Brace
Group: Minnipa Agricultural Centre

Rainfall
Av. Annual total: 326 mm
Av. Growing season: 241 mm
Actual annual total: 278 mm
Actual growing season: 219 mm

Yield
Potential: 2.2 t/ha
Actual: 1.4 t/ha

Paddock History
2001: chemical fallow

Soil
red-brown calcareous sandy loam

Plot size
1.6 x 10 m

Key Messages

- **Selenium is an effective anti-cancer agent, so increasing its content in wheat may improve human health.**
- **Soil or foliar application of selenate to wheat at rates from 100-300 g/ha are effective methods to increase grain selenium concentration on a high-pH soil. Soil application was more effective than foliar.**
- **Selenate applied at up to 300 g/ha does not affect grain yield.**
- **Soil at the Minnipa site has a high available Se level.**
- **Soil selenate treatment at Minnipa was around four times more effective than at Strathalbyn (soil pH of 6.8).**

Why do the trial?

The aim of the trial was to assess the effect of selenium (Se) application rate and method on grain Se concentration in wheat. This has not been done before in Australia. Se is an effective anti-cancer agent. The current Se intake of adult Australians is around 75 µg/day, whereas optimum intake is likely to be around 130 and 240 µg/day for females and males, respectively. Most Australians obtain around half their dietary intake of Se from wheat-based products. This trial investigated the enhancement of Se level in wheat as a strategy to increase population Se intake.

How was it done?

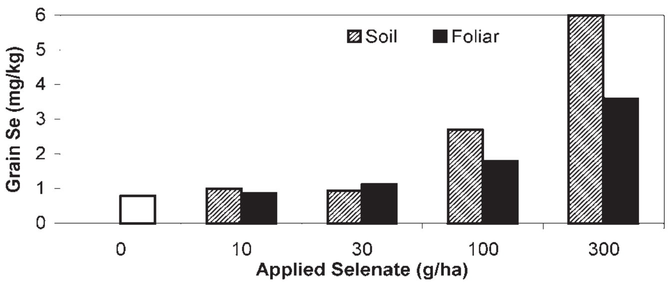
Krichauff wheat was sown on 13 June at Minnipa Agricultural Centre (pH 8.3 at the surface) with 10:22 applied with the seed at 50 kg/ha. Two application methods (soil: sodium selenate in solution sprayed onto the soil immediately prior to seeding, or foliar: selenate with surfactant sprayed onto the plants 10 days after flowering, at the early milky stage) were tested at 5 application rates (0, 10, 30, 100 & 300 g/ha of selenate). Four replicates were used. The same trial was conducted at Charlick (near Strathalbyn) on a clay loam over limestone (pH 6.8 at the surface).

Grain yield was measured and samples of grain from each plot analysed for Se and other minerals.

What happened?

- Grain from plots without any applied Se averaged nearly 800 µg/kg of Se, indicating high levels of native Se.
- There was no effect of Se on grain yield. Average yield for the Minnipa trial was 1.42 t/ha and for Strathalbyn was 1.83 t/ha.
- There was no effect of Se application on grain concentration of other minerals.
- Native levels of available Se were very variable across both trial sites.

Fig 1: Effect of applied Se on grain Se concentration (Minnipa 2002)



- There was little effect on grain Se concentration of Se application at the low rates of 10 & 30 g/ha.
- The high rates of Se application (100 & 300 g/ha) were effective in increasing grain Se concentration.
- At the higher rates, soil application of Se was more effective than foliar application ($P<0.01$).
- Available soil Se at Minnipa was around 13 times that at Strathalbyn.

What does this mean?

- Selenate application, either soil or foliar (but particularly soil), to wheat grown on a high-pH soil could provide a cost-effective means for a food company to produce grain with an enhanced Se level. This would enable consumers to achieve optimum Se intake without the need for supplements, and the Se would be mostly in the desirable selenomethionine form.
- Further research: anti-cancer trials using rat and mouse models to assess different Se forms.

Acknowledgements

- To GRDC for funding the project.
- To Dr Bob Holloway's team at Minnipa for managing the trial.
- To Waite Analytical Services for analysis of grain samples.

Grains Research & Development Corporation

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Pr70 RELEASE
Evaluation on EP Calcareous Soils

Alison Frischke

SARDI, Minnipa Agricultural Centre

Location
Penong

Red Site
Bill & Laura Oats

Rainfall
2002 GSR: 187 mm
2002 Total: 213mm
Ave Annual: 319mm

Potential Yield
1.54 t/ha (wheat)
Soil type: red moderately calcareous sandy loam
Colwell P: 27 mg/kg
Calcium Carbonate: 14%
pH: 8.8

Grey Site
Garth & Maryanne Michell

Rainfall
2002 GSR: 161mm
2002 Total: 192 mm
Ave Annual: 254 mm

Potential Yield
1.02 t/ha (wheat)
Soil type: grey highly calcareous sandy loam
Colwell P: 40 mg/kg
Calcium Carbonate: 67%
pH: 8.6

Plot size
13 x 1.5 m x 4 reps

Other factors
dry conditions, mice damage

Key Messages.

- **Pr70 RELEASE™ did not improve plant vigour or grain yields in 2002 on the calcareous soils of Far West or Central Eyre Peninsula.**
- **In most cases, fluid fertilisers improved grain yields of cereal crops sown in trials on calcareous soils where phosphorus tie-up is a problem.**

Why do the trial?

A seed treatment called Pr70 RELEASE™ has recently been released by Australian Seed Inoculants Pty. Ltd, which has had some success in promoting early seedling vigour and phosphorus uptake, with subsequent yield improvements. The product is recommended for situations where phosphorus levels are likely to be lower in a rotation, and where there is phosphorus tie-up in the soil. The active ingredient is a species of naturally occurring fungi called Penicillium radicum, which has been shown to release unavailable phosphorus compounds in the soil, making them more readily available for plant uptake. The product is not intended to replace fertiliser, but rather to use in conjunction with fertiliser to enhance phosphorus uptake. Results with Pr70 RELEASE™ have been varied across the country, according to soil type and the place of the crop in a rotation, ranging from no response, to 10-14% yield improvements. Previous research had been primarily conducted on acid to neutral soil types.

On the calcareous soils of Eyre Peninsula, up to 80% of the phosphorus applied in granular fertiliser is tied up by calcium carbonate making it unavailable for plant growth. Research has shown fluid fertilisers to be more efficient than granular fertilisers, whereby they enhance phosphorus uptake and improve grain yields in these situations.

These trials were conducted to establish whether Pr70 RELEASE™ was able to improve plant vigour and grain yields on a highly calcareous soil type and whether it could further enhance the performance of fluid fertilisers.

How was it done?

Trial Details: Trials were established at Penong on a red and a grey soil type in 2002. All treatments received 10 kg P/ha and 8 kg N/ha. Treatments were wheat variety x fluid or granular fertiliser x +/- Pr70 RELEASE™ as presented in tables 1and 2 below. Krichauff wheat is reputedly P inefficient, while Brookton is P efficient, therefore they were chosen as two varieties to compare at the grey site, which was the site most likely to experience the greatest yield response to phosphorus. At the red site Krichauff and Machete were used. Granular fertiliser was applied as di-ammonium phosphate and urea, while fluid was applied as ammonium polyphosphate and urea ammonium nitrate. Pr70 RELEASE™ was applied to seed immediately prior to sowing at 6 L/tonne grain. The red site was direct drilled on 17th June, and the grey site on 19th June.

Measurements: Early vigour scores, dry matter production at early tillering, plant and tiller counts, grain yield.

What Happened?

At both the red and grey sites, Pr70 RELEASE™ had no effect on plant emergence, vigour scores, early dry matter production or tillering.

Grain yields were below average at both sites. For each grain variety and fertiliser type, the addition of Pr70 RELEASE™ did not improve grain yield over untreated grain (Tables 1 & 2) at either site.

Table 1: Grain Yields at Penong grey site.

Seed Dressing	PENONG GREY			
	Brookton		Krichauff	
	Fluid	Granular	Fluid	Granular
Pr70 RELEASE™	0.47	0.45	0.42	0.44
Nil	0.50	0.44	0.52	0.38
LSD (P=0.05)	0.07			

Table 2: Grain Yields at Penong red site

Seed Dressing	PENONG RED			
	Machete		Krichauff	
	Fluid	Granular	Fluid	Granular
Pr70 RELEASE™	0.41	0.41	0.66	0.58
Nil	0.40	0.37	0.73	0.64
LSD (P=0.05)	ns			

Both sites did however respond to fluid fertilisers. At the grey site, across treatments, fluid fertilisers improved both early dry matter production and grain yields by

12% compared with granular fertiliser. Likewise, at the red site, fluid fertilisers improved early dry matter by 46%, and grain yields by 10% ($P<0.1$).

The only other yield differences were between varieties Machete and Krichauff at the red site, which was expected and support S4 wheat evaluation data.

What does this mean?

Pr70 RELEASE™ did not improve plant vigour or grain yields in 2002 on the red and grey calcareous soils of Far West Eyre Peninsula, where pH is over 8.5, as has occurred in cases reported on soils of pH 4.7 to 6.5 elsewhere in Australia in other seasons.

In previous research it has often been hard to replicate positive growth responses to biological growth promoters seen in pots or field trials, again in the field. The hostile soils of the Far West, hosting high pH's, and toxic levels of boron, salt and carbonate, are no exception, and coupled with a below average rainfall year in 2002, did not provide a favourable environment or season for the success of Pr70 RELEASE™.

However, the improved availability of nutrients in fluid fertilisers compared with granular fertilisers has produced growth and grain yield responses at these same sites in 2001 and 2002. If considering adopting a fluid fertiliser system, the response to applications of fluid fertilisers over a few seasons, coupled with the current season prices, need to be considered.

Acknowledgements

The work was funded by the GRDC and would not have been possible without the product supplied by Australian Seed Inoculants Pty Ltd., the valuable assistance of Bill Oats, Garth Michell and Shane Doudle, Wade Sheppard and Leigh Davis, SARDI, Minnipa Agricultural Centre.

A FARMER'S EXPERIENCE

Peter & Nathan Hitchcock, Lock and Neil Cordon,

Extension Agronomist EP farming systems, Minnipa Agricultural Centre

Location
Lock
Peter & Nathan Hitchcock

Rainfall
Av Annual: 375 mm
Av GSR: 250 mm
2002 Total: 274 mm
2002 GSR: 216 mm

Yield Potential
2.1 t/ha (wheat)
Paddock History:
2001: Pasture
2000: Wheat

Soil Type
Calcareous sandy mallee

Other factors
Dry Conditions

Why do the trial?

There are many products on the market with a range of yield enhancing claims, so when I was able to get some Pr70 RELEASE™ through Elders at Cleve, it was an ideal opportunity to evaluate this product on a small area of my farm, i.e. provide an economic yield advantage. I have taken a keen interest in the Fluid Fertiliser Research on Upper Eyre Peninsula, however the idea of using a seed coating which will enhance phosphorus efficiency appealed to me.

How was it done?

Yitpi wheat was pickled with Vitafloc®, and treated seed had Pr70 RELEASE™ applied @ 6 L/tonne. This was sown on 23 cm row spacings at 74 kg/ha on the 19th June. Single demonstration strips compared nil fertiliser +/- Pr70 RELEASE™, and DAP Zn 2% @ 60 kg/ha +/- Pr70 RELEASE™.

What happened?

Throughout the season there were no visual differences between any of the strips including the nil area. Come harvest time there was little difference between the nil and the Pr70 RELEASE™ treatment, and similarly there was little difference between DAP Zn 2% applied with, or without Pr70 RELEASE™.

Table 1: Wheat yields at Lock from PR 70 RELEASE™, demo.

Treatment	Protein %	Screenings %	Yield (t/ha)
Nil	13.1	0.3	1.03
Nil fert + Pr70 RELEASE™	13.1	0.4	0.99
DAP Zn 2% + Pr70 RELEASE™	13.7	0.6	1.23
DAP Zn 2%	13.9	2.0	1.28

What does this mean?

- On this soil type it appears that use of the seed dressing Pr70 RELEASE™ did not provide an economic yield advantage over the district practice.
- This un-replicated data supports the replicated trials conducted by Alison Frischke at Penong and reported in this article.

Acknowledgements

I wish to thank Darren Peach from Elders, Cleve, for his guidance in laying down the strips and assistance through the Year, and Australian Seed Inoculants Pty. Ltd. for supplying the Pr70 RELEASE™.

Section

7

Section editor: Liz Guerin

Land Management Consultant

Pirsa Rural Solutions, Streaky Bay

Soils

Soil is one of the fundamental building blocks of your farming system, and in the past have been too often the 'poor cousin' in terms of research priorities.

However, with the growing appreciation of the need for a farming systems perspective, research into many soils type issues has increased. On Eyre Peninsula we have been at the forefront of innovative soil nutrition research; been investigating ways to economically improve non-wetting sands and saline lands and looking at various subsoil constraints. Combined with much of the other research being undertaken such as controlled traffic to reduce soil compaction, yield mapping and various disease interactions, these are exciting and challenging times.

Subsoil Nutrition Summary

What is the best of our knowledge from four years of work?

Samantha Doudle and Nigel Wilhelm

SARDI, Minnipa Agricultural Centre

Given the results we have achieved to date (figure 1), we would advise anyone thinking of experimenting with subsoil nutrition to firstly thoroughly investigate paddock records and soil analysis for the area they are planning. If there is a history of nitrogen, phosphorus or trace element responses, those nutrients should form the basis of your mix. It would be worth experimenting with various mixes for your area, including the complete mix of nitrogen, phosphorus, copper, zinc and manganese. Understanding your soil type and management history may reduce the cost of the exercise as you may be able to eliminate various nutrients that are unnecessary for your situation from the subsoil mix. On the other had there may be other nutrients, such as sulphur or potassium, not in the mix we have used, that would improve your results.

Subsoil nutrition has worked best when we can encourage root growth into the A2 horizon of sandy soils, where there are historically very few stored nutrients or organic carbon - a "nutritional desert". We are unsure at this stage if the ripping responses we receive are always as a result of breaking physical compaction barriers or whether there is also an element of encouraging quick root growth through the nutritional desert and into the more fertile clay underneath. Ripping responses are renown for being unreliable across seasons and soil types- you can't predict when or where they will occur. A response to ripping in your area can only be determined by trying it yourself over a number of seasons. The results from 2002 also suggest that in a sand over clay profile, the depth to clay may be important; try a spot where the sand is at least 30-40 cm deep, because it is in these situations that our results have been most reliable and demonstrated the largest benefits.

Placing nutrients deep within the soil profile to encourage deeper and more prolific root growth has proven very successful in a low rainfall area like Eyre Peninsula. The advantage in this area is that there is not so much rain that nutrients are leached prior to the plant reaching them. Another advantage of placing nutrients into the subsoil is that generally good soil moisture is maintained for most of the growing season compared to the topsoil. Plants can't absorb nutrients from dry soil.

Our best hope for placing nutrients deep within the soil profile without the expense or hassle of deep ripping is by using pressure injection. Brendan Frischke of Minnipa Ag Centre will be investigating pressure injection options over the next four years as part of the GRDC funded "Fluid Fertilisers - the next step towards raising yield potential" project.

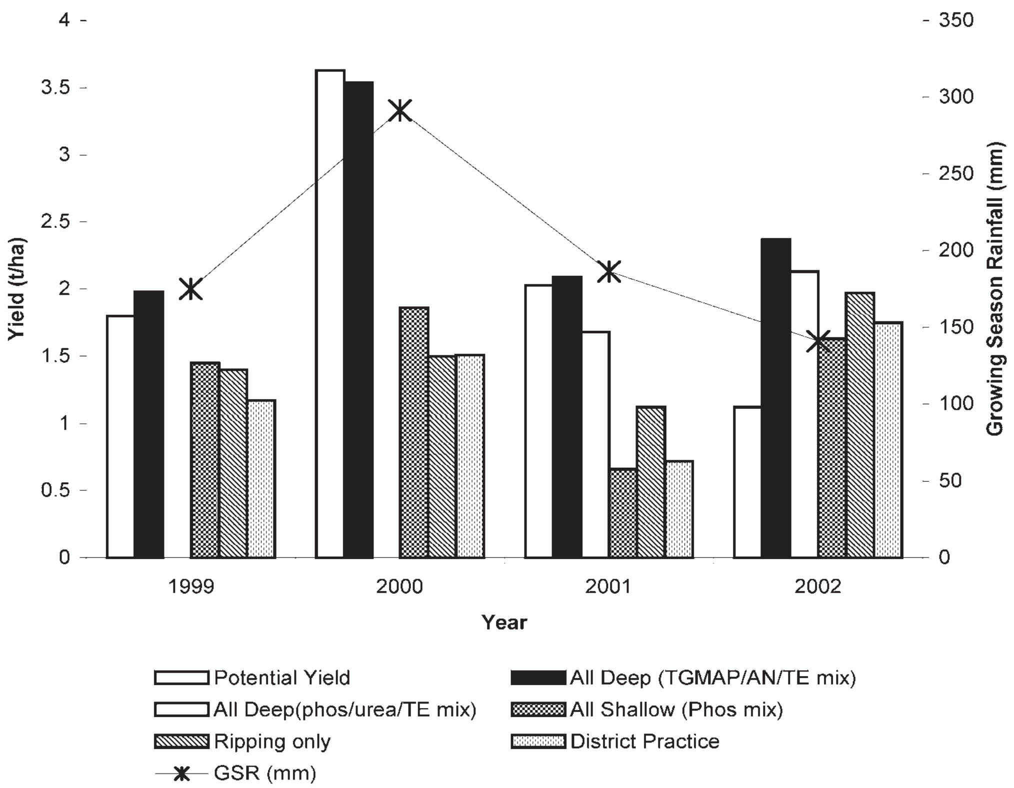

Figure 1: Comparison of similar subsoil nutrition treatments at Wharminda over four years, from 1999 to 2002. (NB: there were no "all deep phos mix" treatments in 1999 or 2000). Average GSR at Wharminda is 199 mm.

TGMAP = tech grade MAP, AN = ammonium nitrate, phos = phosphoric acid, TE = zinc sulphate + manganese sulphate + copper sulphate

Subsoil Nutrition - what kind works where and how deep does it need to be?

Samantha Doudle and Nigel Wilhelm

SARDI, Minnipa Agricultural Centre

Key Messages Box

- **Placement of a combination of fertilisers to a depth of 40 cm was the highest yielding treatment for the fourth year in a row at Wharminda and also performed well at a range of sandy sites across Eyre Peninsula last year.**
- **Ripping to a depth of 20 cm with fertiliser was also beneficial but it was usually worth going the extra to 40 cm.**
- **Deep ripping only provided a yield increase at most sites, as it has in previous dry years.**

Why do the trial?

To determine which combinations of nutrients drive yield increases from improved subsoil nutrition across a variety of soil types and climatic conditions on upper EP.

In 1999 the Wharminda Ag Bureau became involved with the EP Farming Systems project with the aim of investigating ways to improve nutrition on their inherently infertile sandy soils. Using applications of a combination of nutrients distributed throughout the soil profile to 40 cm massively increased yield in 1999, 2000 and 2001 (EP Farming Systems (EPFS) Summary 1999, pg 72 / EPFS Summary 2000, pg 100 / EPFS Summary 2001, pg 112). In 2002 subsoil investigation sites were expanded to include sandy soils at Wharminda, Kelly (south east of Kimba) and Condada (north west of Minnipa). The focus of each site was to assess the most effective and economical combination of nutrients, rates and application depth for each soil type.

How was it done?

Deep ripping machine: para plow. All trials rolled after ripping.

Treatments: all nutrients applied as fluid fertilisers - Phosphoric Acid (H_3PO_4), Urea, Zinc Sulphate ($ZnSO_4$), Manganese Sulphate ($MnSO_4$), Copper Sulphate ($CuSO_4$), Tech Grade MAP (TGMAP), Ammonium Nitrate (AN)

Measurements: tissue tests, early dry matter, yield, grain nutrients, screenings, protein

Gross Margins: Gross margin calculations included the cost of deep ripping and rolling. Deep ripping estimates are based on the actual cost to use the machine, not a contracted rate nor including the purchase price of a deep ripper. To put this in perspective, a $15,000 ripper (capable of delivering fluid nutrition to a depth of 40 cm) used on 1,500 ha per year and which lasts for 10 years, would add approx $1.00/ha to the gross margin cost.

Base Price - Krichauff, ASW = $228.11. Approximate para plow deep ripping costs: 40 cm = $20/ha, 20 cm = $15/ha

Location
Closest town: Wharminda
Cooperator: John Masters
Group: Wharminda Ag Bureau

Rainfall
10 yr av annual total: 272 mm
10 yr av. GSR: 198.6 mm
2002 annual total: 209 mm
Actual growing season: 141 mm

Yield
Potential: 1.12 t/ha
Actual paddock: 0.8 t/ha

Paddock History
2002: Frame wheat
2001: Grass free, medic dominant pasture
2000: Schooner barley
1999: Excalibur wheat

Soil
Land System: Dune swale
Major soil type description: 30 - 40 cm siliceous sand over sodic clay

Diseases
Some rhizoctonia and crown rot

Plot size
1.5 x 20m

Other factors
Only 10mm in Sept and 14.5 mm in Oct set crop back severely, when it was starting to take off and demand moisture. Up until then it was looking like an above average crop. Lots of abortive tipping.

Table 1: Trial Details

Location	Wharminda	Kelly - clayed	Kelly - unclayed	Minnipa
Ripping & Nutrient Placement date	May 7th	May 3rd	May 3rd	May 16th
Sowing Date	June 11th	June 4th	June 4th	June 9th
Base Fertiliser	------------------------------ 60 kg/ha of 18:20 just below the seed ------------------------------			
Wheat variety	Krichauff	Krichauff	Krichauff	Yitpi
Soil Type	10-40 cm of sand over sodic clay	Deep sand (over 1m deep). Clay spread @ approx 200t/ha in Sept 2001.	Deep sand (over 1 m deep)	Deep sand dune (over 1 m deep). Problem area in paddock
Site input costs (treatment costs in Tables 2 & 3)	$69.57	$62.00	$65.00	$65.37
Type of experiment	Small plot, replicated	Small plot, replicated	Small plot, replicated	Small plot, replicated

Soils

Location
Closest town: Kimba
Cooperator: Gary & John Grund
Group: Kelly Landcare Group

Rainfall
Av. Annual total: 340 mm
Av. Growing season: 240 mm
Actual annual total: 231mm
Actual growing season: 189 mm

Yield
Potential: 2.1 t/ha
Actual: 0.7 t/ha

Paddock History
2001: Pasture
2000: Pasture
1999: Pasture

Soil
Land System: low hills with sand spreads
Major soil type description: deep siliceous sand over clay

Plot size
1.5 x 20m
Other factors
Low growing season rainfall

Table 2: Treatments used in "What kind works where?' trials. NB: 18:20 @ 60 kg/ha was applied just below the seed in all treatments @ seeding, urea was the N source in all deep N treatments while H3PO4 was the P source in all deep P treatments except Supermix where TGMAP was used.

Treatment	Deep Nutrients (kg/ha)	Depth of placement (cm)	*Treatment Cost ($/ha)
TGMAP Supermix	34N + 20P + 10Zn + 10Mn + 4Cu	40	$239
All	34N + 20P + 2Zn + 3Mn + 2Cu	40	$142
N + P	34N + 20P	40	$115
P + TE	20P + 2Zn + 3Mn + 2Cu	40	$117
N + TE	34N + 2Zn + 3Mn + 2Cu	40	$74
TE	2Zn + 3Mn + 2Cu	40	$49
Rip only	-	40	$22
District Practice	-	5	$0
All Shallow	34N + 20P + 2Zn + 3Mn + 2Cu	5	$122

**Treatment costs only include the cost of extra fertiliser or deep ripping used in that treatment, over and above the input costs common to all treatments.*

Table 3: Treatments used in "How deep?" trials. NB: 18:20 @ 60 kg/ha was applied just below the seed in all treatments @ seeding, urea was the N source in all deep N treatments and H3PO4 was the P source in all deep P treatments. This trial was not conducted at the Kelly Sand site.

Treatment	Deep Nutrients (kg/ha)	Depth of Placement (cm)	Treatment Cost ($/ha)
All shallow	34N + 20P + 2Zn + 3Mn + 2Cu	5	$122
All top 20 *	34N + 20P + 2Zn + 3Mn + 2Cu	20	$137
All bottom 20 **	34N + 20P + 2Zn + 3Mn + 2Cu	20-40	$142
All deep ***	34N + 20P + 2Zn + 3Mn + 2Cu	40	$142
District practice	-	5	$0

** ripped to 20 cm and nutrients applied throughout top 20 cm*
*** ripped to 40 cm and nutrients applied throughout bottom 20 cm of rip, ie. from 20 to 40 cm*
**** ripped to 40 cm and nutrients applied throughout entire 40 cm*

What Happened ?

What Kind Works Here ?

Deep ripping only

All sites benefited from deep ripping only, except for Minnipa. The two sites with a history of more intensive cropping, hence more vehicular traffic in the paddock over the years, produced the greatest yield increase from deep ripping alone, they were Wharminda (13% or 0.23 t/ha, figure 1) and Kelly Clay (26% or 0.18 t/ha, figure 2).

Nutrient combinations plus deep ripping

On top of the benefits from deep ripping, the yield at all sites increased with the addition of nutrients placed throughout the soil profile. Increases from adding a combination of nutrients to the ripping operation ranged from 19% or 0.38 t/ha at Wharminda (figure 1) to 103% or 0.4 t/ha at Minnipa (figure 4).

The best combination of nutrients across all sites in 2002 was the mix of nitrogen (N), phosphorus (P) and trace elements (TEs) (copper, zinc and manganese). Various combinations of N + TEs or P + TEs performed well at all sites, however N and P combined were generally slightly lower yielding compared to one or the other combined with the TE mix.

Gross margins

At Wharminda, the best gross margins were obtained using N + TE @ 40 cm, TE only @ 40 cm, N + P + TE @ 40 cm and ripping only to 40 cm (figure 1). All of these treatments returned a higher gross margin than district practice (by $24-37/ha), despite including deep ripping and/or higher nutrient costs.

At Kelly Clay four treatments returned a reasonable gross margin - ripping only to 40 cm, TE only @ 40 cm, TE +N @ 40 cm and district practice (figure 2).

At Kelly Sand all gross margins were poor due to low yields. The best treatments were district practice, ripping only to 40 cm and N + TE @ 40cm (figure 2).

At Minnipa the only positive gross margins were N + TE @ 40 cm and ripping only to 40 cm (figure 3).

Rates

The only trial comparing a high and low rate of nutrients was conducted at Wharminda. Unfortunately this experiment was located on a site with a shallow depth of sand to clay and there was no grain yield response to nutrition, despite early dry matter increases, so does not allow us to compare the effect of nutrient rates. However, figure 4 shows a comparison of yields and gross margins of high vs low rates over the last three years. Similar to conventional fertiliser delivery systems, high rates of fertiliser only increased yield and profit in the year with above average growing season rainfall, 2000. This was the only year that a high rate of nutrient mixes placed to 40 cm in the subsoil returned a higher gross margin than a half or third rate. There was no difference in yield between the two rates in 2001 or 2002, both years having lower than average GSR so there was a large penalty in gross margin with the high nutrient rate.

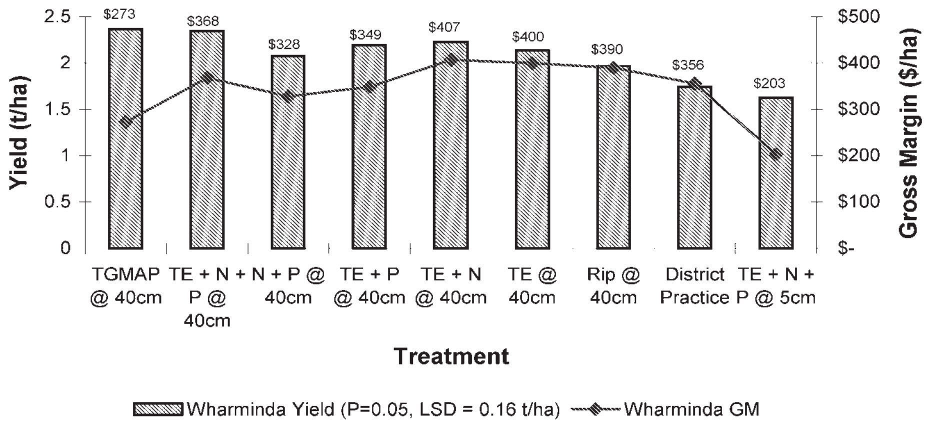

Figure 1: Yield and gross margin estimations for Krichauff wheat in the "What kind works where?" trial at Wharminda, 2002.

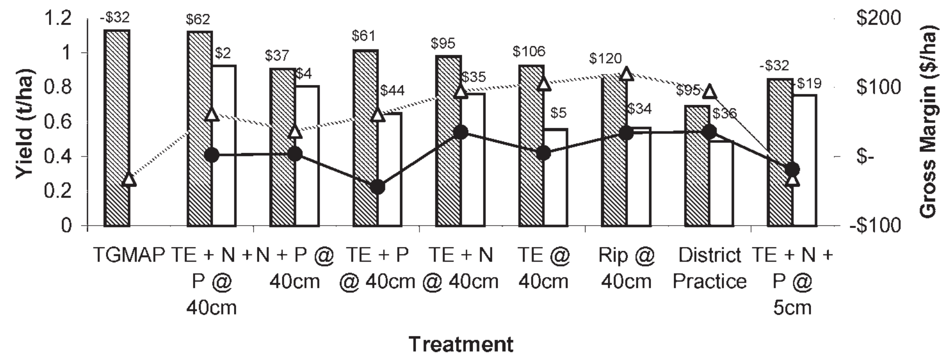

Figure 2: Grain yield of Krichauff wheat in the "What kind works where?" trials at Kelly Clay and Kelly Sand, 2002

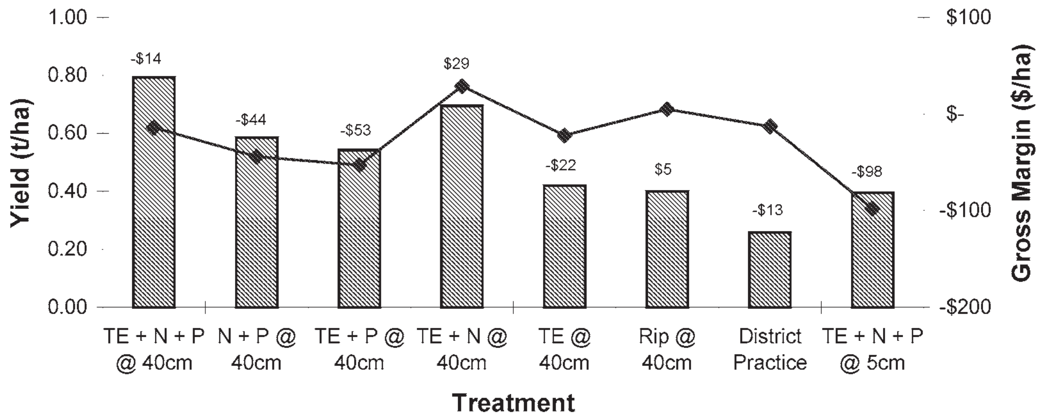

Figure 3: Grain yield and gross margin of Yitpi wheat in the "What kind works where?" trial at Minnipa, 2002.

Location
Closest town: Kimba
Cooperator: Trevor Inglis
Group: Kelly Landcare Group

Rainfall
Av. Annual total: 369 mm
Av. Growing season: 269 mm
2002 annual total: 217 mm
2002 GSR: 194 mm

Yield
Potential: 2.18 t/ha

Paddock History
Pasture for approx 10 years

Soil
Land System: low hills with sand spreads
Major soil type description: deep siliceous sand over clay

Plot size
1.5 x 20m

Other factors
Low growing season rainfall

Location
Closest town: Minnipa
Cooperator: Matt & Amanda Cook

Rainfall
Av. Annual total: 296 mm
Av. Growing season: 229 mm
Actual annual total: 228 mm
Actual growing season: 178 mm

Yield
Potential: 1.86 t/ha
Actual: 1.0 t/ha

Paddock History
2001: medic (Targa)
2000: wheat
1999: medic

Soil
Land System: plains with sand ridges
Major soil type description: "Big White" sand dune, closely related to "Big Red" in Simpson Desert!

Plot size
1.5 x 20m

Other factors
Crop suffered from poor emergence due to wind damage and sandblasting, which continued all season. Rabbit damage.

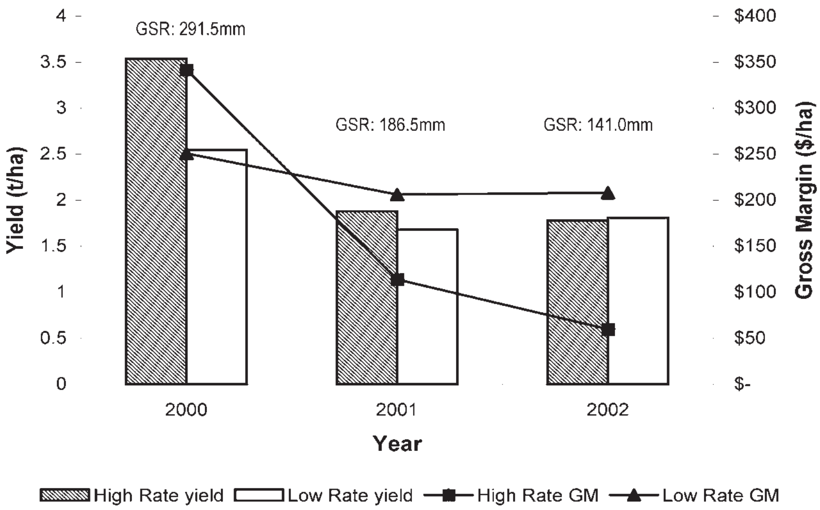

Figure 4: Comparison of high vs low subsoil nutrient rates on grain yield and gross margin of cereal in each year from 2000 - 2002, at Wharminda. (NB: Gross margins used average wheat price from 1999 - 2002. 10 year average GSR at Wharminda: 199 mm)

*** 2002Yield and gross margin data used in this graph was from Experiment 4 at Wharminda, which was located on very shallow sand where there was no response to ripping or subsoil nutrition. This data was used because it was the only experiment at Wharminda in 2002 with different nutrient rates. A gross margin $398 was obtained from the same low rate of nutrient treatment on deeper sand at the same site in 2002(figure 1).*

Table 4: Products and rates used in figure 4.

High Rate	Rate: 34N, 20P, 10Zn, 10Mn, 4Cu Product: TGMAP/ AN/TE mix	Rate: 34N, 20P, 10Zn, 10Mn, 4Cu Product: H_3PO_4/ urea/TE mix	Rate: 68N, 25P, 4Zn, 10Mn, 4Cu Product: H_3PO_4/ urea/TE mix
Low Rate	17N, 10P, 5Zn, 5Mn, 2Cu Product: TGMAP/ AN/TE mix	Rate: 10N, 5P, 2Zn, 2Mn, 1Cu Product: H_3PO_4/ urea/TE mix	Rate: 34N, 20P, 2Zn, 3Mn, 2Cu Product: H_3PO_4/ urea/TE mix

The highest yielding treatments at all sites were the two that included ripping to 40 cm and either nutrients placed throughout the profile to 40 cm or the same nutrients placed only from 20 - 40 cm in the profile (ie. none in the top 20 cm). The only exception to this was at Wharminda where the top 20 cm equalled the yield of the 40 cm treatment. This has not been the case in the past, nor was it the case in another trial at the same location, where the 40 cm treatment out-yielded the 20 cm treatment by 15% or 0.28 t/ha. The difference between placing nutrients at 40 and 20 cm was even larger using straight shanked ripping tines (refer to the following article, Subsoil nutrition - engineering developments for these details).

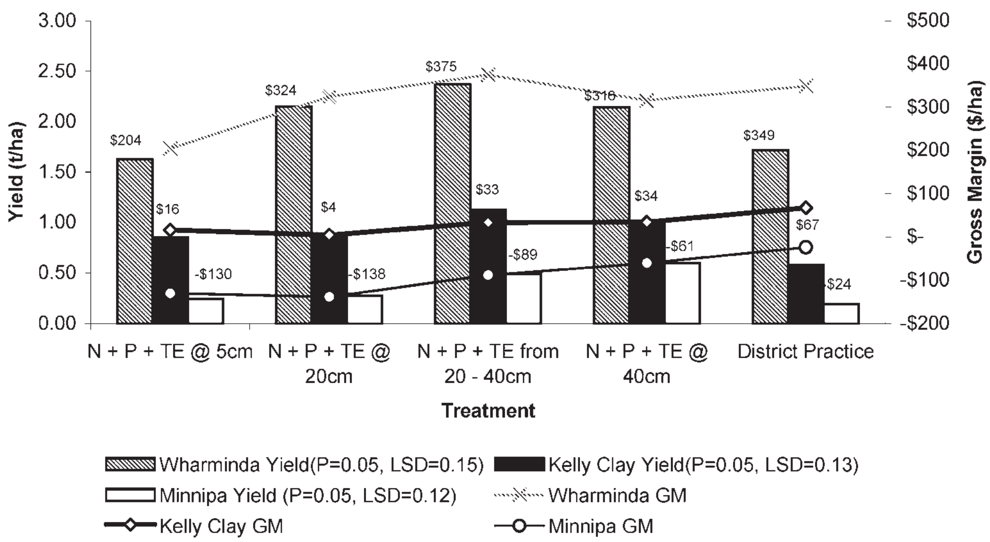

Figure 5: Grain yield of wheat in the "How deep ?" trials at Wharminda, Kelly Clay and Minnipa, 2002.

Placing nutrients from 20 - 40 cm in the soil was clearly the best treatment at Wharminda (0.22 t/ha better 0 - 40 cm) and was equally as good as the 0 - 40 cm treatment at Kelly Clay and Minnipa (figure 5). Grain copper uptake was increased at Wharminda by 20% in the 20 - 40 cm treatment compared to the 0 - 40 cm treatment. At Kelly Clay all treatments with nutrients added increased grain trace element uptake equally, regardless of depth of application.

What does this mean?

Ripping

Ripping increased yield at all sites in 2002, bar one, as it has at Wharminda in the two drier years out of the previous three. The major reasons for these ripping responses are likely to be varied. For example at Kelly Clay the ripping response is likely to be from breaking a hard pan in the sand to allow the roots to access soil moisture deeper in the sand profile. At Wharminda the response to ripping may have two drivers. The first may be the same as Kelly Clay with a compacted layer in the sand. The second may be more to do with breaking the sodic cap on the subsoil clay and allowing the roots to explore this area of the subsoil. There is mounting evidence to justify that some of the subsoil nutrition work in 2003 should focus on trying to investigate the nature and extent of compaction in sand and other subsoil layers of heavier texture on Eyre Peninsula soils. Understanding these soils and how they behave better will help predict when and where deep ripping responses will occur and how deep you need to rip.

Nutrient Combinations

In 2002, as in the previous three years, the best yielding combination and depth of nutrients was N + P + TE placed throughout the soil profile to 40 cm. Adding trace elements to either nitrogen or phosphorus, or both, provides a yield increase that is not usually achieved using any of those three nutrients alone. In the future we need to work out if it is the combination of all trace elements or whether we can isolate that to 1 or 2 depending on soil types and paddock management histories.

Rates

We also need to establish the minimum rates of nutrients which are needed to produce these large yield increases. At present, GM comparisons are very crude because the costs of nutrients used are a major component of the total input costs and yet the rates have been selected in a pretty arbitrary way. Any reductions in rates of nutrients without compromising yield will have a large and positive impact on gross margins. The fact that the ripping + high rates of nutrients operations have actually paid for themselves already in many cases suggests that fine-tuning of the systems may cause substantial improvements in profitability in the future.

Furthermore, in the GM comparisons made so far, no benefits from the deep ripping operations have been allowed for in subsequent years. Any residual benefits from these techniques will have a major and positive impact on the profitability of the operations. Although we have yet to prove any residual benefits in trials on upper EP, there is enough circumstantial evidence from work in other areas to encourage us to keep looking for benefits in subsequent years.

Depth

Once again, adding higher levels of nutrition was not successful at the majority of sites unless the nutrients were placed deep within the soil profile. Visually, the shallow placement at 5 cm looked better early in 2002 than it has in previous years. However when the season started to dry out these shallow treatments rapidly became stressed, compared to their deeper placed counterparts. This highlights an important point, in that there is little point in creating extra yield potential for a crop unless you have also created some way of making more moisture available as well. This can obviously be achieved by overcoming weed and disease problems if they are present. However improving subsoil nutrition stimulates a deeper and more robust root system that is able to better utilise subsoil moisture and nutrients. A thorough understanding of your soil is essential however, because encouraging roots into a subsoil with chemical toxicities such as boron or salt may only end in disaster (this happened in 2002 to the Buckleboo demonstrations on the heavy red flat).

It is encouraging that the treatment with nutrients placed from 20 - 40 cm only is equally as effective, if not better than placement from 0 - 40 cm.

Acknowledgments

• Wharminda farmers and Ed Hunt for creating the initial motivation for this work and their continued direction and support.

• John "Chompy" Masters and family for hosting these trials and assisting us above and beyond the call of duty every year!

• Wade Shepperd, Willy Shoobridge, Brenton Growden and Terry Blacker for unstinting and uncomplaining support throughout the season (actually it was only Wade and Willy who did not complain !)

• The Kelly Landcare Group, in particular Gary & John Grund and Trevor Inglis, the Buckleboo Farm Improvement group, in particular Graham & Heather Baldock and Matt & Mandy Cook from Minnipa, for hosting the trials and assisting with trial management. Particular thanks to Matt for loaning us the "Big White" dune, nice spot!

• GRDC for providing the funding for this research as part of the Eyre Peninsula Farming Systems Project.

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Soils

Subsoil Nutrition Demonstration at Buckleboo

Samantha Doudle

SARDI, Minnipa Agricultural Centre

Location
Buckleboo
Graham and Heather Baldock

Rainfall
Av. Annual total: 304 mm
Av. Growing season: 216 mm
Actual annual total: 188 mm
Actual growing season: 158 mm

Yield
Potential: 1.46 t/ha (wheat)
Paddock Actual: 0.4 t/ha

Paddock History
2001: Janz wheat
2000: chemical fallow
1999: grassy pasture (missed spray topping)

Soil
As per article

Plot size
1.5 x 20 m, unreplicated

Other factors
Frost and early finish

Key Messages

- **You must know and understand your soil types to depth before techniques such as deep ripping with nutrients can be contemplated.**

Why do the trial?

To assess the effect of subsoil nutrition across a range of soil types in the Buckleboo district.

At the request of the Buckleboo Farm Improvement Group (Big Fig), the EP Farming Systems Project established fluid fertiliser and subsoil nutrition research in the area in 2002.

How was it done?

Members of Big Fig and EPFS conducted a preliminary soil survey of the district searching for the elusive one paddock that had the three main soil types from the area represented - grey ground, sand and red ground.

As it was, most farms had paddocks with all three soil types in one paddock but the final choice for a site was on Graham and Heather Baldock's property.

Soil characteristics of the site are described in table 1.

The sandy soil was located across a sand rise which had neutral pH and low organic matter, fertility, salt and boron levels.

The grey soil was alkaline with a surface calcium carbonate level that would suggest a response to fluid P. Nutrients have accumulated in the toxic layers below 42 cm, where there has traditionally been minimal root penetration as a result of the boron, sodicity and salt levels. This grey soil had the highest calcium carbonate levels of the five paddocks sampled in the survey at Buckleboo.

The red soil was located in a localised flat with a very heavy texture, neutral pH and minimal calcium carbonate on the surface. As with the grey soil, toxic levels of boron, salt and sodicity had accumulated in the red subsoil below 20cm, which once again contained high levels of nutrition not accessible to plant roots.

Subsoil nutrition demonstrations were established on each soil type. It must be emphasised that these demonstrations were unreplicated, so conclusions drawn from these results need to be treated with some caution.

Subsoil nutrients were applied on 4th May using a para plow and all trials were rolled after ripping with tractor wheels to smooth the surface for seeding and improve trafficability. Subsoil fertilisers were applied as fluid fertilisers - Phosphoric Acid (H_3PO_4), Urea, Zinc Sulphate ($ZnSO_4$), Manganese Sulphate ($MnSO_4$), Copper Sulphate ($CuSO_4$), Tech Grade MAP (TGMAP)

Table 1: Characteristics of soil types at Buckleboo trial site, 2002.

Paddock	Depth	Texture	CO3	pH (CaCl2)	Boron (Hot HCl)	N/ha kg	Colwell P	Colwell K	OC%	S	ESP%	Approx ECe
Sand	0-11	sand	0.2%	6.2	0.6	21.56	25	178	0.6	3.6	1%	0.74
Sand	11-26	Nt[1]	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt
Sand	26-66	loam	nt	7.7	0.5	22.4	3	116	0.1	2.6	0%	0.39
Paddock	Depth	Texture	CO3	pH (CaCl2)	Boron (Hot HCl)	N/ha kg	Colwell P	Colwell K	OC%	S	ESP%	Approx Ece
Grey	0-8	sandy loam	8%	8.1	0.9	22.4	32	721	1.18	3.8	1%	0.99
Grey	8-42	heavy clay	nt	8.1	1.2	38.08	1	213	0.42	25.2	17%	4.17
Grey	42-79	clay	nt	8.5	13.8	67.34	2	280	0.3	134	33%	8.94
Paddock	Depth	Texture	CO3	pH (CaCl2)	Boron (Hot HCl)	N/ha kg	Colwell P	Colwell K	OC%	S	ESP%	Approx ECe
Red	0-10	heavy clay	0.2%	7.6	1.2	9.8	25	579	1.09	2.7	2%	0.60
Red	10-20	heavy clay	nt	8.3	2.2	4.2	3	443	0.57	16.4	23%	4.29
Red	20-70	heavy clay	nt	8.5	12.4	28.0	2	449	0.3	99.4	34%	10.21

[1] *nt means soil sample not taken or chemical analysis not conducted.*

and Ammonium Nitrate (AN). Trials were sown on 3rd June with Krichauff wheat and a base fertiliser of 60 kg/ha of 18:20 placed below the seed with the following treatments imposed.

Measurements: early dry matter, yield

Treatment	Deep Nutrients (kg/ha)	Depth of placement (cm)
All	34N + 20P + 2Zn + 3Mn + 2Cu	40
N + P	34N + 20P	40
P + TE	20P + 2Zn + 3Mn + 2Cu	40
N + TE	34N + 2Zn + 3Mn + 2Cu	40
TE	2Zn + 3Mn + 2Cu	40
Rip only	-	40
District Practice	-	5
All Shallow	34N + 20P + 2Zn + 3Mn + 2Cu	5

What happened?

Grey Soil:

Extra nutrients increased early dry matter on the grey soil, with deep placed N & P producing double the dry matter of district practice. There was no early dry matter increase from ripping alone. The season became progressively drier and more stressful and final yields were low on this soil type. The lowest yield was deep N & P (0.34 t/ha) suggesting that deep N&P had produced too much growth to be sustained and finished in 2002. Other treatment yields ranged from 0.4 - 0.5 t/ha, with extra nutrient placed shallow producing the highest yield.

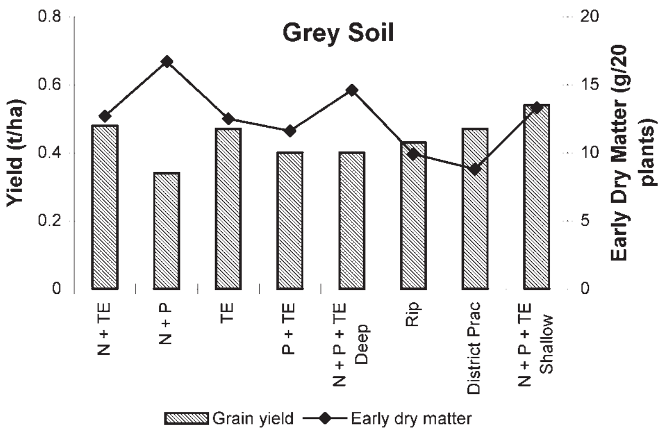

Figure 1: Early dry matter production and grain yield of Krichauff wheat on grey soil at Buckleboo, 2002.

Sand Soil:

Once again there was a large early dry matter increase in several treatments, with N + TE placed deep increasing early dry matter by 75% over district practice. Unlike the grey soil, the extra nutrients placed shallow did not stimulate better early growth. Ripping alone also did not improve early growth. All subsoil nutrition treatments increased yield by approx 0.1 t/ha over the others (except N + P + TE deep, where we pulled up a stump with the ripper and made a mess! - hazard of unreplicated work). The early trends in dry matter did not carry through as a result of the harsh season finish, however the more friendly subsoil did not penalise the treatments with better early growth as much as the other two sites with hostile subsoils.

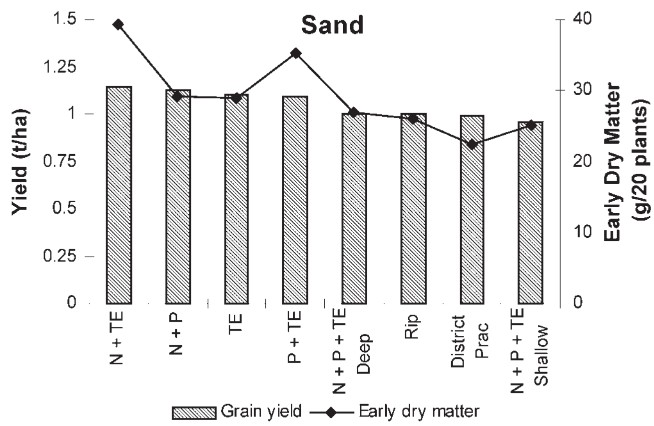

Figure 2: Early dry matter production and grain yield of Krichauff wheat on sand at Buckleboo, 2002.

Red Soil:

Early dry matter differences were unreliable due to seeding problems into the big clods left by the para plow (our primitive rolling technique didn't do much good on this soil type!). Most treatments had early dry matters similar to district practice. All of the plots collapsed in spectacular style as the season progressed, with district practice the only treatment to produce anything resembling grain (0.43 t/ha).

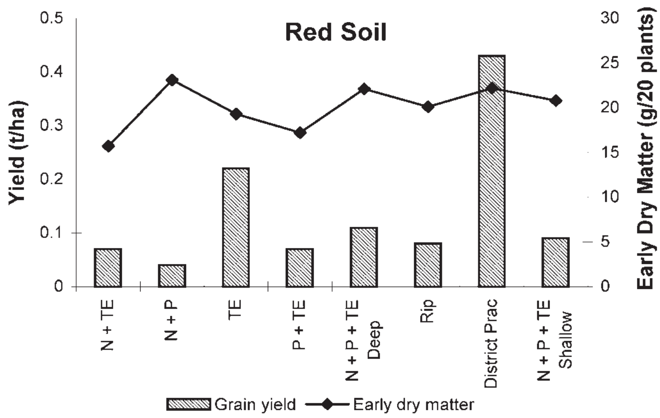

Figure 3: Grain yield and early dry matter on red soil type at Buckleboo, 2002

What does this mean?

Grey Soil:

Given the hostile nature of the subsoil on this soil type and our encouragement of root systems to grow into it with ripping +/- nutrients, it is perhaps understandable that the subsoil treatments were unable to capitalise on their good early growth.

Sand Soil:

The early growth trend did not carry through as a result of the harsh season end, however the more friendly subsoil did not penalise the treatments with better early growth as much as the other two sites with hostile subsoils.

Red Soil:

ouch - why would anyone encourage roots to go down there? 2002 was not the year for heavy textured soils with hostile subsoils.

This was a great demonstration site throughout the year, as it really highlighted the differences between soil types, particularly subsoils. The key message that came out of this work has already been mentioned in previous subsoil nutrition papers in this book, however it is very important so I'll mention it again. Before undertaking the expense and hassle of experimenting with subsoil nutrition on your place, make sure you understand what your soil is like first. Until our cereal breeders come up with varieties that don't mind living in subsoils like some found in the Buckleboo area (and much of upper EP for that matter) there is no point in encouraging our crop roots to go down there with deep ripping and/or subsoil nutrition.

Acknowledgments

Thanks go to Brume and Heather for the trial site, assistance to set up the trials and late night chats on the UHF. My special thanks to Brenton Growden and Terry Blacker from Port Lincoln for their entertaining assistance with seeding and Wade Shepperd and Willie Shoobridge for technical assistance during the year.

This work was funded by GRDC.

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Key to symbols

Subsoil Nutrition - engineering developments

Samantha Doudle, Nigel Wilhelm and Brendan Frischke

SARDI, Minnipa Agricultural Centre

Location
Closest town: Wharminda
Cooperator: John Masters
Group: Wharminda Ag Bureau

Rainfall
10 yr av annual total: 272 mm
10 yr av. GSR: 198.6 mm
2002 annual total: 209 mm
Actual growing season: 141 mm

Yield
Potential: 1.12 t/ha
Actual paddock: 0.8 t/ha

Paddock History
2002: Frame wheat
2001: Grass free, medic dominant pasture
2000: Schooner barley
1999: Excalibur wheat

Soil
Land System: Dune swale
Major soil type description: 30-40 cm siliceous sand over sodic clay

Diseases
Some rhizoctonia and crown rot

Plot size
1.5 x 20m

Other factors
Only 10mm in Sept and 14.5 mm in Oct set crop back severely, when it was starting to take off and demand moisture. Up until then it was looking like an above average crop. Lots of tipping in the heads.

Key Messages Box

- **Straight-shank ripping tines were more effective than the bent-shank tines used so far on EP for subsoil nutrition work.**
- **There was no benefit to adding nutrients to deep ripping on very shallow sand (10-15 cm) at Wharminda in 2002 but there was on sand 20-40 cm deep.**

Why do the trial?

To compare the effect of tine type, depth of working and horizontal spacing on the performance of subsoil nutrition.

Since 1999 the EP Farming Systems subsoil nutrition research program has used a 3-tined, bent-shank para plow to place nutrition at depth. Bent-shank tines, whilst extremely effective, are not easily purchased in Australia. With sponsorship from the Advisory Board of Agriculture, AusPlow and GRDC (through the Fluid Fertiliser Engineering project), the EPFS project constructed a straight-shank deep ripping machine, capable of varying tine depth and horizontal tine spacing. These trials aimed to compare the original bent-shank para plow with the new straight-shank version and to investigate how close the straight-shank tines need to be for maximum subsoil nutrition impact.

How was it done?

Ripping & nutrient placement date: May 11th

Sowing date: June 11th

Base Fertilisers: 60 kg/ha of 18:20 just below seed

Variety: Krichauff wheat

Deep ripping machine used: para plow or straight-shanked deep ripper. NB: all treatments were rolled after ripping. Treatments: all applied as fluid fertilisers - Phosphoric Acid (H_3PO_4), Urea, Zinc Sulphate ($ZnSO_4$), Manganese Sulphate ($MnSO_4$), Copper Sulphate ($CuSO_4$)

Measurements: tissue tests, early dry matter, yield, grain nutrients, screenings, protein

What happened?

Straight vs Bent

There were two features noticed when using the new straight-shank ripper tine. The first was that it required more horse power to pull than it's bent-shank counterpart. The second was that it left the soil fluffier than the bent-shank machine, causing problems with traction on following passes (rolling, seeding, etc). Despite both of these problems grain yield was still higher using the straight-shank machine, producing 0.3 t/ha more yield than bent-shanks at 40cm depth (on both the ripping and ripping + nutrient treatments) (see table 1) and 0.1 t/ha at 20 cm depth. Nutrients placed to 40 cm lifted yields by 0.2 t/ha with either deep ripper, and by 0.1 t/ha at 20 cm. Yields without ripping or deep nutrients ("district practice") were 1.8 t/ha at this site which means that the best combination of deep ripping plus nutrients lifted yields by 0.7 t/ha (and to levels more than double the potential), despite a year with growing season rainfall only

Table 1: Effect of deep ripper design and deep nutrients on grain yield of Krichauff wheat at Wharminda in 2002. NB: DAP @ 60 kg/ha was applied just below the seed in all treatments @ seeding. Tine spacing for all treatments was 50 cm. LSD (P=0.05) for grain yield is 0.1 t/ha.

Type of shanks	Deep Nutrients (kg/ha)	Depth of Ripping (cm)	Treatment Cost ($/ha)	Grain yield (t/ha)	Gross Margin ($/ha)
Bent (para)	34N + 20P + 2Zn + 3Mn + 2 Cu	40	$ 140	2.2	$ 323
Straight	34N + 20P + 2Zn + 3Mn + 2 Cu	40	$ 140	2.5	$ 555
Bent (para)	34N + 20P + 2Zn + 3Mn + 2 Cu	20	$ 137	1.9	$ 258
Straight	34N + 20P + 2Zn + 3Mn + 2 Cu	20	$ 137	2.0	$ 282
Bent (para)	-	40	$ 20	2.0	$ 391
Straight	-	40	$ 20	2.3	$ 345
Bent (para)	-	20	$ 15	1.8	$ 363
Straight	-	20	$ 15	1.9	$ 382

Table 2: Effect of deep ripper tine spacings and deep nutrient rates on yield of Krichauff wheat at Wharminda in 2002. NB: DAP @ 60 kg/ha was applied just below the seed in all treatments @ seeding and a straight-shanked ripper to 40 cm was used in all treatments.

Width between tines (cm)	Deep Nutrients (kg/ha)	Treatment Cost ($/ha)	Grain yield (t/ha)	Gross Margin ($/ha)
30	-	$ 27	1.7	$ 328
50	-	$ 22	1.7	$ 336
75	-	$ 17	1.7	$ 322
30	34N + 20P + 2Zn + 3Mn + 2 Cu	$ 147	1.8	$ 216
50	34N + 20P + 2Zn + 3Mn + 2 Cu	$ 142	1.8	$ 234
75	34N + 20P + 2Zn + 3Mn + 2 Cu	$ 137	1.7	$ 213
30	68N + 25P + 4Zn + 10Mn + 4 Cu	$ 268	1.6	$ 58
50	68N + 25P + 4Zn + 10Mn + 4 Cu	$ 263	1.8	$ 106
75	68N + 25P + 4Zn + 10Mn + 4 Cu	$ 258	1.7	$ 80

70% of average.

How close do straight shanked tines need to be?

There was little impact of tine spacing on grain yields in this trial (see table 2). However, these results should be regarded with some caution because unlike all other trials at this site, there was no response to adding a balanced mix of nutrients to the deep ripping process. This was apparently due to the shallow depth of sand under this trial. Subsequent site investigation revealed that the depth of sand over clay in this area (10-15 cm) was shallower than the rest of the 2002 program and any other trial site we have previously used (ranging from 20-40 cm). So this trial may not have been a fair test of the effect of tine spacing on deep ripping benefits either.

What does this mean?

Straight vs Bent

We think that the straight-shank deep ripping tines may have ripped slightly deeper than the bent ones, therefore breaking up more of the sodic cap on the subsoil clay. This would explain some of the extra power required to pull the tines. However it may have allowed the crop in these plots to access more subsoil moisture when the stressful periods came later in the season. Both rippers had different ripping foot designs and this may also have provided some of the difference, with the foot on the straight shank potentially creating more soil disturbance.

Distance between tines

There were no conclusive results from this trial in the very dry and harsh conditions of 2002 but it does suggest that wide gaps between ripper tines may still be effective. This result is encouraging because it will reduce the cost of operation per hectare. Adding nutrition to deep ripping in this trial on very shallow sand at Wharminda produced no yield increase at all. This experiment will be conducted again across a variety of seasons and soil types.

The future

Trial work in 2003 will continue to investigate the effects of ripping depth, tine spacing, tine shape and nutrient placement. Recognising that application cost is a major constraint to the successful adoption of this work, alternative techniques of applying nutrient at depth that are more cost effective will also be investigated. Briefly some of those alternatives are:

- Disc coulters with liquid fertiliser delivery capabilities.
- High pressure injection of fertiliser solutions.
- Combinations of high pressure injection with coulters or deep rip tines.

Acknowledgments

- Wharminda farmers and Ed Hunt for creating the initial motivation for this work and their continued direction and support.
- John "Chompy" Masters and family for hosting these trials and assisting us above and beyond the call of duty every year!
- GRDC for providing the funding for this research as part of the Eyre Peninsula Farming Systems Project.
- Advisory Board of Agriculture for providing funding for the new ripper.
- Ausplow (WA) for providing sponsorship and advice for the new ripper.
- Shane Doudle & Brendan Frischke for designing and constructing the new ripper.
- Brenton Growden and Terry Blacker for sowing the trials and Wade Shepperd, Willy Shoobridge and Jon Hancock for assisting with trial measurements and harvest.

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Residual Benefit of Subsoil Nutrition

***David Davenport*[1] *and Neil Cordon*[2]**

[1]Rural Solutions SA, Pt Lincoln, [2]Extension Agronomist, EP Farming Systems Project.

Location
Closest town: Edillilie
Cooperator: Edillilie Landcare Group

Rainfall
Av. Growing season: 380 mm
2002 growing season: 244 mm

Yield
Potential: 3.08 t/ha
Actual: 2.24 t/ha

Paddock History
2001: Schooner Barley
2000: Pasture

Soil
Land System: gently undulating plains with sand over sodic clay.
Major soil type description: yellow sodosol

Plot size
4 reps x 22m x 1.65m

Key Messages Box

- **Subsoil nutrition placed at 20 cm has provided a residual yield benefit in the second year at Edillilie.**
- **Yield increases were higher where trace elements were also applied.**

Why do the trial?

To determine if placement of nutrients into the subsoil provides any residual benefits to crops in the second year following application. Increasing subsoil nutrition appears to have potential to increase yield on sands and sand over clay soils. The economic return of subsoil nutrition would be significantly improved if there were residual benefits. It is therefore important to identify if any yield increases occur in subsequent crops and for how many seasons. This information can then be used to determine if subsoil nutrition is economically viable and at what intervals treatments should occur.

How was it done?

This trial was established in 2001 to compare:

- 3 forms of nitrogen (sulphate of ammonia, ammonium nitrate and urea)
- 2 depths of fertiliser (N & P) placement - standard (sowing depth) or deep (20 cm)
- 2 timings of N application - split application or seeding application
- 2 trace element application methods - deep placement or foliar

In 2001 no difference was observed between the different forms of nitrogen, the timing of application or the depth of application. However, problems with sowing depth on the deep applications resulted in low levels of emergence which are thought to have affected the validity of comparing the deep and shallow applications.

In 2002 the plots were resown.

Pre Sowing:

Roundup @ 1.5 L/ha + Goal @ 300 ml/ha.

Roundup @ 1 L/ha + Treflan @ 1.5 L/ha + Spark @ 75 ml/ha.

Sowing: 21/06/2002

Keel barley @ 70 kg/ha with 80 kg/ha of 18:20 applied with the seed

Early tillering:

urea @ 50 kg/ha

Hoegrass @ 1.5 L / ha + Hoemix @ 1.4 L / ha + wetter.

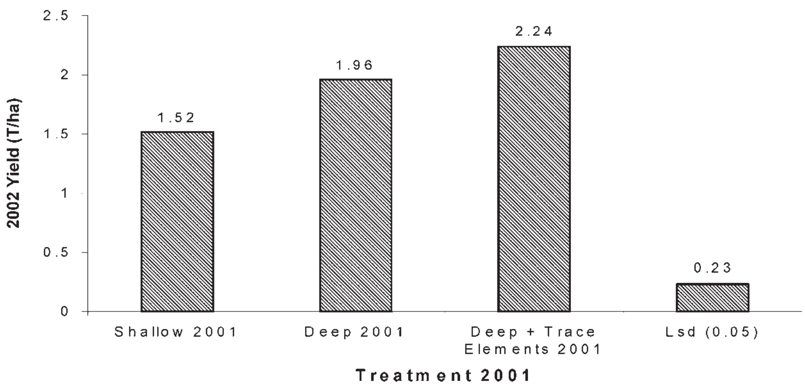
Foliar spray Cu (746 ml/ha), Zn (1.32 L/ha), Mn (3.468 L/ha)& Fe (4.5 L/ha).

What happened?

High levels of root disease were observed throughout the trial, however even from early tillering the sites with subsoil applied trace elements showed better colour and vigour. Visual status was somewhat supported by tissue analysis (YEBS) with the nil trace element plots showing zinc levels bordering on marginal.

There was a residual yield benefit on plots with N & P placed in the subsoil and a further yield increase on plots that received subsoil trace elements (Figure 1).

Figure 1: Edillilie Nitrogen Form & Placement Trial Residual Effects 2002



What does this mean?

- Large residual benefit was achieved from placing nutrients at 20 cm in the year prior to these results. This benefit may have been further increased by the addition of trace elements (there were no shallow treatments with trace elements applied so no conclusions can be made comparing deep and shallow placement of trace elements).

Soils

- The trial will be monitored in 2003 to determine if any further residual benefit occurs.
- NB: Over the past three years similar trials have been conducted on the subsoil nutrition experiments at Wharminda as part of the EP Farming Systems project. No residual yield benefits were observed in 2000 or 2001 and in 2002 the barley crop on the site failed. Despite this, there were increased levels of copper, manganese and zinc in the grain from the plots that received deep placed trace elements the previous year. These trials will also continue to be monitored in the future.

Acknowledgments

The Edillilie Farming Systems site is an initiative of the Edillilie Landcare group and is funded by the One Million Hectares project - a joint GRDC and NDSP project. Support is also provided by HiFert, Incitec, Carrs' Seeds, ABB.

Replicated trial work conducted by Brenton Growden and Terrance Blacker, SARDI, Port Lincoln.

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CARRS'SEEDS

Trace Element application methods on clay

Samantha Doudle and Nigel Wilhelm

SARDI, Minnipa Agricultural Centre

Location
Closest town: Kimba
Cooperator: Gary & John Grund
Group: Kelly Landcare Group

Rainfall
Av. Annual total: 340 mm
Av. Growing season: 240 mm
2002 total: 231mm
2002 GSR: 189 mm

Yield
Potential: 2.1 t/ha
Actual: 0.7 t/ha

Paddock History
2001: Pasture
2000: Pasture
1999: Pasture

Soil
Land System: low hills with sand spreads
Major soil type description: deep siliceous sand over clay

Plot size
1.5 x 20m

Other factors
Low growing season rainfall.
Common root rot

Key Messages Box

- **Deep placed trace elements can be more effective than the same amount placed just below the seed.**
- **A foliar application of trace elements was just as effective as deep placement at increasing yield.**
- **Deep placement increased grain uptake of all nutrients, compared to other methods of TE application.**

Why do the trial?

To determine the most effective method of applying trace elements to crops growing on a sandy soil that has been clay spread.

One of the major nutritional problems encountered with clay spreading is induced trace element deficiencies as a result of applying heavy rates of clay with a high pH. Recognition that this problem occurs and is wide spread on Eyre Peninsula clay spread paddocks is essential. This trial then takes the next step of identifying the most effective way to manage the problem.

How was it done?

Ripping & subsoil nutrient placement date: May 3rd

Sowing date: June 4th

Base Fertilisers: 60kg/ha 18:20 just below seed

Variety: Krichauff wheat

Foliar TE application date: September 5th (late tillering)

Deep ripping machine used: para plow

Treatments: all applied as fluid fertilisers - Phosphoric Acid (H_3PO_4), Urea, Zinc Sulphate ($ZnSO_4$), Manganese Sulphate ($MnSO_4$), Copper Sulphate ($CuSO_4$)

Measurements: tissue tests, early dry matter, yield, grain nutrients, screenings, protein

What happened?

Placing trace elements throughout the soil profile to 40 cm was more effective than placing them with the seed, which is an effect we have also seen in subsoil nutrition trials at Wharminda. However, yields were the same when TE's were either placed deep or applied later in the season as a foliar spray (figure 1).

Deep placement increased copper and manganese uptake into plants at late tillering compared to shallow placement. However, zinc uptake was the same in all treatments, including the control, where no zinc was applied.

Deep placement increased uptake of all elements applied, apart from nitrogen, into the grain, when compared to all other treatments (table 2).

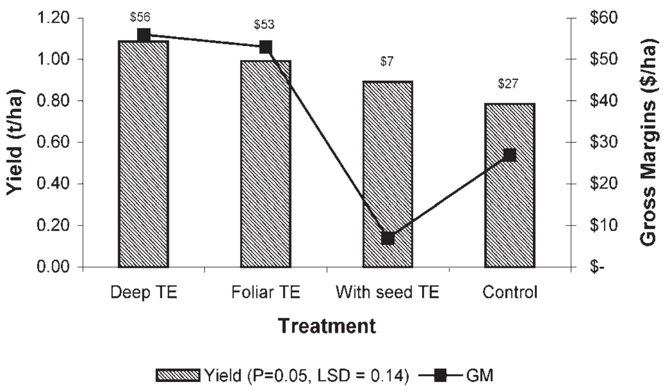

Figure 1: Yield and gross margin estimations for Krichauff wheat in the "Trace element application methods?" trial at Kelly Clay, 2002. NB: these gross margins include the cost of placing nitrogen and phosphorus as subsoil nutrition..

Table 1: Treatments used in Trace Element Application Methods on Clay Experiment at Kelly Clay 2002.

	Treatment	TE application NB: Treatment 3 TE applied prior to seeding with N & P		
		Product	Rate (units/ha)	Depth (cm)
1	Foliar TE	$ZnSO_4 + MnSO_4 + CuSO_4$	0.33 Zn + 1.1 Mn + 0.1 Cu	Foliage
2	With seed	$ZnSO_4 + MnSO_4 + CuSO_4$	2 Zn + 3 Mn + 2 Cu	5
3	Subsoil	$ZnSO_4 + MnSO_4 + CuSO_4$	2 Zn + 3 Mn + 2 Cu	40
4	Nil	$ZnSO_4 + MnSO_4 + CuSO_4$	0 Zn + 0 Mn + 0 Cu	0
-----All treatments also received 34 N + 20 P (urea & H_3PO_4) @ 40cm, prior to seeding -----				
-------- All treatments also received 60 kg/ha of DAP just below the seed @ seeding--------				

Soils

Table 2: Uptake of various nutrients into the grain of Krichauff wheat at Kelly Clay, 2002.

	Uptake of nutrients in grain (g/ha), P=0.05				
Treatment	Cu	Mn	Zn	P	N
Deep TE	1.39	22.9	29.1	3519	2653
Foliar TE	0.95	12.7	23.9	2844	2415
With seed TE	0.87	13.3	21.2	2771	2290
Control	0.71	13.6	23.1	2761	2052
LSD (P=0.05)	*0.22*	*2.9*	*4.2*	*516*	*300*

What does this mean?

Unlike subsoil nutrition treatments at the Wharminda site, the best yield from this experiment was only 51% of potential yield. This indicates that there were factors that were not measured that were restricting grain yield. Two possible causes for the poor yields were sulphur deficiency (plant sulphur levels at late tillering were marginal to deficient) or wide spread incidence of common root rot in the trial. RDTS results also highlighted low levels of Rhizoctonia, Pratylenchus and Crown Rot at this site.

Despite the lower yields, for the second year running, deep placed trace elements have outperformed those placed conventionally, immediately below the seed, and have equalled the performance of a trace element foliar spray. Once again the finish to the season was harsh, drying the topsoil and reducing the ability of the plant to use trace elements placed close to the soil surface. The majority of trace elements applied at depth would have remained in moist soil all growing season, keeping them available to the crop throughout its growth. Given the lower amount of TE applied as a foliar spray, and therefore the lower cost, if the two treatments were compared on a single year's performance, then the foliar application would be the clear winner.

However, in previous year's subsoil nutrition research we have discovered that despite there being no residual yield advantage to the following barley crop, the subsoil treatments are still providing higher levels of trace elements in the grain of the following crop. To date we have not followed this through on more than 1 year. These results suggest that deep soil applied trace elements may correct a problem for several years, which needs to be included in any cost comparison with a foliar spray which will have no residual benefits.

Placing trace elements at depth may have other advantages, that we have not yet captured in this research. For example, could there be a residual benefit to your farming system in the following year for rhizoctonia control or will you be able to get your foliar spray out exactly when you want to for maximum effectiveness (it may be too wet, too windy....) ? Trace elements applied to the soil will be available to the plant from the day that seed is planted in the ground, encouraging good root development and strong cell walls, which both help to reduce the effects of rhizoctonia. Perhaps residual subsoil trace elements will allow flexibility in chemical use, allowing an SU to be used without having to wait 6-8 weeks before a foliar trace element application can be made. Once applied, trace elements are likely to stay available in the soil from 2 to 40 years, depending on the type and rate used and the particular soil type. Current knowledge suggests copper would stay in the soil profile the longest, followed by zinc then manganese..

Acknowledgments

- The Kelly Landcare Group, in particular Gary & John Grund for hosting the trials and assisting with trial management.
- GRDC for providing the funding for this research as part of the Eyre Peninsula Farming Systems Project.
- Brenton Growden and Terry Blacker for seeding the trials. Wade Shepperd, Willy Shoobridge and Jon Hancock for assisting with trial measurements and reaping.

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Key to symbols

Clay Spreading with highly calcareous clays

Shane Malcolm[1], Samantha Doudle[2] and David Davenport[3]

[1]Farmer Wharminda, [2]SARDI, Minnipa, [3]PIRSA Rural Solutions Pt Lincoln

Key Messages Box

- **Clay spreading with calcareous clay can induce manganese deficiency.**
- **Type and rates of clay and the effect on pH needs to be considered.**
- **Single foliar trace element application may not be sufficient to correct deficiencies.**

Why do the trial?

"To assess the benefits of various clay rates, types of clay and deep ripping on my farm at Wharminda".

Shane Malcolm has been clay spreading for 6 years and has often left portions of paddocks non-clayed to provide a comparison. From these areas he has observed that while clay spreading has had a major impact on reducing erosion, yields from clayed areas have not shown significant improvement and in some cases appeared to be lower than on non-clayed areas. Tissue analysis has previously indicated manganese deficiency in previous years. In 2002, Shane set up strips in three paddocks to compare various treatments so he could begin to understand why clay spreading is not returning a consistent crop improvement on his property.

How was it done?

The sites selected were:

Site 1: A broad gully with deep sand over clay in the valley floor with shallow sand over clay on the rises.

Site 2: A flood plain with coarse alluvial quartz, sand and gravels with red clays at depth.

Site 3: A rise of deep siliceous sand.

What happened?

Site 1: There was no significant difference in yield across the three treatments however, low levels of manganese in the grain from the 100 t/ha clayed treatment indicates that where the higher rates of calcareous clay was used, yield may have been affected by manganese tie up.

Site 1	Yield	Grain Analysis (mg/kg)			
Treatment	(t/ha)	Cu	Mn	Zn	P
0t	0.99	2.46	11.28	26.28	3500
70t	1.10	2.45	15.74	28.6	3733
100t	1.09	2.47	6.83	23.97	3267
LSD (P=0.05)	0.08	ns	5.87	ns	143.4

Site 2: No significant differences in yield or in grain analysis levels.

Site 2	Yield	Grain Analysis (mg/kg)			
Treatment	(t/ha)	Cu	Mn	Zn	P
Clay + Rip	0.69	3.44	18.3	52.4	3967
0t	0.75	2.77	20.5	34.4	3533
0t + rip	0.84	2.99	22.5	39	3733
LSD (P=0.05)	ns	0.39	ns	10.08	272.4

Table 1: Types of clay used in Shane Malcolm's clay spreading demonstrations

Paddock	Depth	Texture	CO_3	pH (CaCl)	DTPA Mn**	DTPA Cu	DTPA Zn	Boron (Hot HCl)	kgN/ha	Colwell P	Colwell K	OC%	S	Exc. Ca	Exc. Mg	Exc. Na	Exc. K	ESP	Approx. ECe
Site 1	surface	clay	1.9%	8.2	1.45	0.21	0.44	4.2	9.8	26	375	0.71	2.9	7.89	2.95	0.4	0.98	3%	1.06
Site 2	surface	loam	0.2%	7.1	1.53	0.22	0.45	2.8	22.4	20	556	0.82	6	9.25	2.94	0.3	1.46	1%	1.14
Site 3	surface	loam	2.5%	8.2	1.39	0.27	0.43	5	43.4	15	364	0.77	7.1	9.1	3.13	0.6	0.89	3%	1.75

** Note that soil DPTA manganese is not considered a reliable indicator of manganese availability, particularly on high pH soils. Also that clay samples were collected from the surface of the paddock at harvest in 2002 and it is therefore likely that the ECe, boron, ESP are now lower than when it was originally spread. However given other information, soil salinity and sodicity levels are not considered to be an issue on any of the sites. It is also thought that problems with laboratory method has resulted in carbonate levels much lower than tests conducted at the site have shown. The natural pH of sands in this area are generally neutral and the addition of clay appears to have raised pH more on sites 1 and 3 than on site 2. This could be due to differences in clay type and/or the amount spread.

Location
Closest town: Wharminda
Cooperator: Shane Malcolm
Group: Wharminda Ag Bureau

Rainfall
Av. Annual total: 330 mm
2002 annual total: 214 mm
2002 growing season: 167 mm

Yield
Potential: 1.74 t/ha
Actual: 0.69-1.72 t/ha

Plot size
1.6 m x 30 m strips taken out with plot header (3 strips from each treatment)

Table 2: Management details for all sites

	Spreading Details	2002 Sowing Details
Site 1	9/3/00: Spread with Multi Spreader @ 70 t/ha 3/8/00: Sprayed Zn @ 1 l/ha, Mn @ 1.25 kg/ha, Cu @ 0.3 l/ha	24/5/02: Pre-drill urea @ 38 kg/ha 11/6/02: Sprayed Treflan @ 0.8 l/ha, Roundup @ 0.4 l/ha. Sowed Krichauff with 18:20 @ 60kg/ha. 18/7/02: Sprayed MCPA @ 0.35 l/ha, Diuron @ 165 g/ha. 9/8/02: Sprayed Zn @ 1 l/ha, Mn @ 1.5 kg/ha, Cu @ 0.2 l/ha
Site 2	16/4/99:Clay @ 150 – 220 t/ha, Smudged with wideline 6/5/99: Sprayed Zn @ 1.8 kg/ha, 29/2/00: Worked clay with 2-way disc 7/8/00: Sprayed Zn @ 1 l/ha, Mn @ 1.25 kg/ha, Cu @ 0.3 l/ha,	25/5/02: Predrilled urea @ 36 kg/ha. 10/6/02: Sprayed Treflan @ 0.8 l/ha, Roundup Max @ 0.4 l/ha. Sowed Westonia with 18:20 @ 60kg/ha. 21/7/02: Sprayed MCPA @ 0.5 l/ha. 24/8/02: Sprayed Zn @ 1 l/ha, Mn; @ 1.5 kg/ha, Cu @ 0.25 kg/ha.
Site 3	16/4/99: Clayed at 300 t/ha, smudged with wideline and prickle chain. 26/4/99: Sprayed Zn @ 4.37 kg/ha, Cu @ 2.5 kg/ha. 28/4/99: Worked deep with wideline and prickle chain 10/8/99:Sprayed Mn @ 2.8 kg/ha 29/2/00: 2-way disc clay	25/5/02: Pre drilled urea @ 36 kg/ha – very soft. 11/6/02: Sprayed Treflan @ 0.8 l/ha. Sowed Krichauff with 18:20 @ 60 kg/ha. 23/7/02: Sprayed MCPA @ 0.35 ml/ha, Ally @ 3 g/ha. 25/8: Sprayed Mn @ 1.5 kg/ha, Cu @ 0.25 kg/ha.

Site 3: Nil clay recorded a yield advantage compared to the 300 t/ha of clay with trace element treatment. Nil clay with trace elements recorded a further yield increase. Deficient levels of manganese were found in grain from the 300 t/ha clay treatment.

Site 3	Yield)	Grain Analysis (mg/kg)			
Treatment	(t/ha	Cu	Mn	Zn	P
300t + TE	1.02	2.11	6.89	23.9	2667
0t	1.33	1.89	12.28	24	3000
0t + TE	1.72	2.09	14.14	20.8	2773
LSD (P=0.05)	0.36	ns	2.74	ns	ns

What does this mean?

This is not a replicated trial and there is always some difficulty in quantifying the impact of different treatments however, there are 2 basic conclusions to come from this work:

1. High rates of clay and in particular the use of calcareous clays has had an effect on manganese availability resulting in deficiency levels in the grain.
2. A single foliar spray has not been sufficient to overcome low manganese levels in the grain.

This data is consistent with existing knowledge that increasing pH will reduce manganese availability as does high levels of calcium carbonate. Also it supports previous demonstration work conducted on clayed ground at Edillilie in 2000 where trace elements, including manganese applied below the level of incorporated clay resulted in yield increases in barley. It would appear that lower clay rates would reduce the effect but low rates of clay may not provide any significant yield increase. Further work is required to identify the most effective and economical means of supplying manganese to clay spread soils.

Acknowledgments

Shane Malcolm, Wharminda.

Wade Shepperd for assistance with reaping.

Using Lime to Change Soil pH at Edillilie

David Davenport[1] Neil Cordon[2]

[1]Rural Solutions SA, Pt Lincoln, [2]Rural Solutions SA, Minnipa

Location
Closest town: Edillilie
Cooperator: Edillilie Landcare Group

Rainfall
Av. Growing season: 380 mm
2002 growing season: 244 mm

Yield
Potential: 3.08 t/ha
Actual: 2.39 t/ha

Paddock History
2001: Schooner Barley
2000: Pasture

Soil
Land System: gently undulating plains with sand over sodic clay.
Major soil type description: yellow sodosol

Plot size
4 replicates, 22 m x 1.65 m

Key Messages Box

- **Significant yield loss occurred in Keel barley on a sand over clay when the pH ($CaCl_2$) was lowered from 4.8 to 4.5**
- **No yield increase was obtained when pH ($CaCl_2$) was increased above 4.8.**

Why do the trial?

To determine the pH at which crop yields are affected by acidity at Edillilie.

It is well known that soil acidity can reduce crop production mainly through the influence of aluminium which becomes more available as the soil becomes more acidic. Aluminium levels vary depending on climatic factors and in particular soil types (heavier soils tend to have higher aluminium levels than sands at the same pH). Sand over clay soils at Edillilie are generally acidic in the range of 4.2-5.0 pH($CaCl_2$) and the Edillilie Landcare Group recognised the need to obtain data to determine at what pH level farmers should be applying lime on sand over clay soils.

How was it done?

The trial was established in 2001. The natural pH of the site was 5.0 ($CaCl_2$) and elemental sulphur @ 500 kg/ha was added to all plots to reduce pH. A further 500 kg/ha was added in one treatment to further reduce pH. Other treatments had lime sand applied @ 1.5 t/ha and incorporated to 10 cm.

Schooner barley was sown @ 90 kg/ha with 100 kg/ha of 18:20 and sulphate of ammonia @ 133 kg/ha.

Soil trace elements were also added in some treatments to ensure deficiency did not occur.

There were no significant differences in yield 2001 and pH tests indicated that the sulphur applied had little effect on pH (probably due to low solubility of elemental sulphur).

In 2002 the plots were resown, all with the same treatment.

Pre Sowing:

Roundup @ 1.5 L/ha + Goal @ 300 ml/ha.

Roundup @ 1 L/ha + Treflan @ 1.5 L/ha + Spark @ 75 ml/ha.

Sowing: 21/06/2002

Keel barley @ 70 kg/ha with 80 kg/ha of 18:20 applied with the seed.

Early tillering:

Urea @ 50 kg/ha.

Hoegrass @ 1.5 L / ha + Hoemix @ 1.4 L / ha + wetter.

What happened?

The plots with extra sulphur appeared less vigorous with poorer colour than other treatments. This difference became obvious at tillering and increased as the crop advanced. High levels of root disease were observed throughout the trial.

Soil pH tests in October 2002 showed that the sulphur was impacting on pH (table 1).

Table 1: pH soil tests taken at Edillilie in 2002 across a range of treatments applied in 2001.

Treatment	pH (CaCl)
Nil (500 kg/ha of Sulphur in 2001)	4.8
Sulphur treatment (1 t/ha Sulphur in 2001)	4.5
Lime treatments (1.5 t/ha in 2001).	5.2

The yield results show that there was a difference between the nil (pH($CaCl_2$) 4.8) and the sulphur treatment (pH($CaCl_2$) 4.5). There was no difference between the nil and the limed treatments (Figure 1).

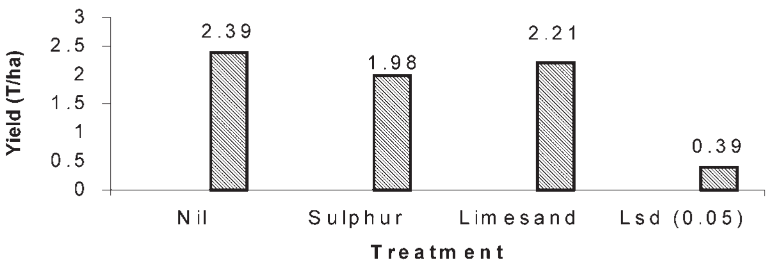

Figure 1: 2002 yield results from Edillilie pH trials

Soils

What does this mean?

- Significant yield loss occurred in Keel barley on a sand over clay when the pH ($CaCl_2$) was lowered from 4.8 to 4.5
- The results suggest that acidity is not affecting yields of barley (and probably wheat, which is more tolerant of acidity) at a pH ($CaCl_2$) of 4.8 or higher on sands at Edillilie.
- At pH ($CaCl_2$) 4.5 farmers could expect a yield penalty on barley.
- Take home message - on sand over clays at Edillilie, liming at 1-1.5 t/ha should be undertaken when pH($CaCl_2$) falls below 4.8 to prevent loss of yield (NB: liming at higher rates than 1.5 t/ha on sandy soils can induce manganese deficiency).

Acknowledgments

The Edillilie Farming Systems site is an initiative of the Edillilie Landcare group and is funded by the One Million Hectares project - a joint GRDC and NDSP project. Support is also provided by HiFert, Incitec, Carrs' Seeds, ABB.

Replicated trial work conducted by Brenton Growden and T.A. Blacker, SARDI, Port Lincoln.

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Carrs' Seeds

Clay Spreading at Wharminda

Samantha Doudle

SARDI, Minnipa Agricultural Centre

Location
Closest town: Wharminda
Cooperator: Jeff & Jodie Jones
Group: Wharminda Ag Bureau

Rainfall
Av. Annual total: 327 mm
Av. Growing season: 302 mm
2002 annual total: 223mm
2002 growing season: 142 mm

Yield
2002 Potential: 0.6 t/ha
2002 Average 0.36 t/ha

Soil
Major soil type: sand dunes & swales over sodic clay
Clay used for spreading
Clay %: 25 - 35%
ESP: 19%, pH: 9.4 (water)
Free lime: moderate
Boron: 5.7 mg/kg

Plot size
10 m x 40 m x 3 reps

Other factors
very low growing season rainfall

Key Messages Box

- **250 t/ha applied in 1999 with shallow incorporation performed poorly in 2002, a very dry season.**
- **Most claying treatments recouped their initial clay spreading cost after the fourth year of the trial.**
- **The claying rates returning the consistently highest gross margins are between 50 and 100 t/ha.**

Why do the trial?

This long-term trial was established with the Wharminda Ag Bureau in 1999 to determine the most economic and effective combinations of clay rate and incorporation depth for water repellent sands in eastern Eyre Peninsula's low rainfall areas. Most of the work with clay spreading repellent sands prior to this trial have been in areas wetter than the eastern EP. Local farmers were concerned that they may not gain the same benefits on eastern EP with its clays of different geology and with hot dry finishes being so common. Details of the performance of this trial in previous years can be found in EP Farming Systems (EPFS) Summary 1999, pg 74, EPFS Summary 2000, pg 107 and EPFS Summary 2001, pg 117.

How was it done?

1999 Treatments

Clay was added at 4 rates and incorporated to two depths

1. 0 t/ha Control
2. 50 t/ha + shallow incorporation (approx 10 cm)
3. 50 t/ha + deep incorporation (approx 20 cm)
4. 100 t/ha + shallow incorporation
5. 100 t/ha + deep incorporation
6. 150 t/ha + shallow incorporation
7. 150 t/ha + deep incorporation
8. 250 t/ha + shallow incorporation
9. 250 t/ha + deep incorporation

1999: Clay spreading date: 8th April 1999. Clay incorporation date: 14th & 15th April 1999. Sown to Sloop barley, 22nd June

2000: Sown to Herald (3 kg/ha) and Parabinga (4 kg/ha) medic on 12th April, using small seed spreader, followed by harrows.

2001: 6 m wide strip deep ripped across all plots on 4th May 2001. Sown to Frame wheat @ 70 kg/ha with 65 kg/ha 18:20.

2002: Sown to Merrit Lupins @ 95 kg/ha on 26th May with 60 kg/ha of 18:20 . Foliar trace element spray MnSO4 & CuSO4 in Sept.

Measurements - early dry matter, yield, seed weight.

What happened?

A late and difficult start to the 2002 season caused sand blasting on the emerging lupins and hot dry winds during the growing season caused many of the lupin flowers to abort and plants to suffer moisture stress, reducing the final yield (figure 1). Despite this there were still some interesting highlights from this trial.

Grain Yield

The best treatments in 2002 were 100 and 150 t/ha. Grain yields with 50 and 250 t/ha were intermediate between these two rates and the control. Visually, plots with 250 t/ha of clay and shallow incorporation were poor all season (250 t/ha and deep incorporation was OK). Our initial explanation for this was that there was still too much free lime from the clay in the topsoil of these treatments, which caused the lupins to suffer from lime chlorosis early in the growing season. There were no plant symptoms of lime chlorosis when checked during late September, however the plots were still noticeably thinner. No differences occurred in plant dry matters taken at this stage, which suggests that the thin look of the crop may have been due to poor emergence/establishment and therefore less plants on these plots rather than poorly growing plants (there were no emergence counts done in 2002).

Another possible explanation for the poor performance of the 250 t/ha shallow treatment could be related to soil moisture in 2002, the driest year we have had so far for this trial. The plants on the 250 t/ha shallow treatment may have suffered more moisture stress than other treatments because the topsoil they were growing in had a heavier texture, making it more difficult for the crop to extract soil moisture from the often dry topsoil.

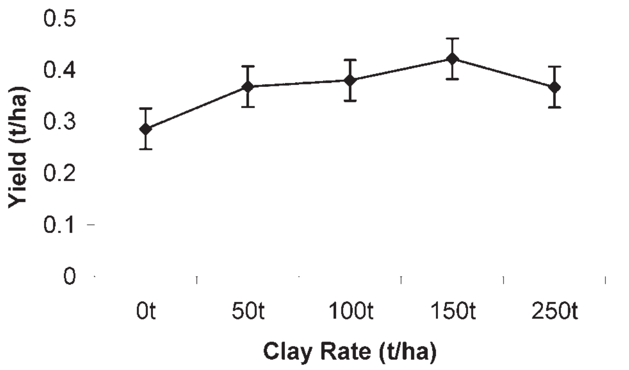

Figure 1: Effect of clay on grain yield of Merrit lupins at Wharminda Clay Spreading Trial, 2002. Each point is the average of shallow and deep incorporation at each rate. Vertical bars are the LSD at P=0.05.

Finances

2002 has put a dent in the upward trend of the cumulative gross margin graphs for some treatments (figures 2 & 3). The poor performance of lupins on the 250 t/ha shallow incorporated plots has meant that this treatment has yet to recoup the clay spreading and incorporation costs, even after 4 years of subsequent production. However, there are still several treatments performing better than the no clay control - 100 t/ha shallow incorporation and 150 t/ha shallow & deep incorporation. Figure 2: Years to recoup clay spreading expenses from shallow incorporated treatments, Wharminda clay spreading trial

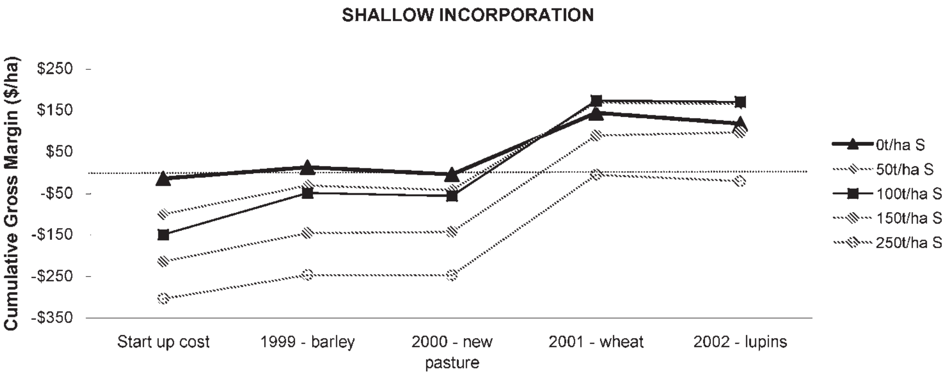

Figure 2: Years to recoup clay spreading expenses from shallow incorporated treatments, Wharminda clay spreading trial

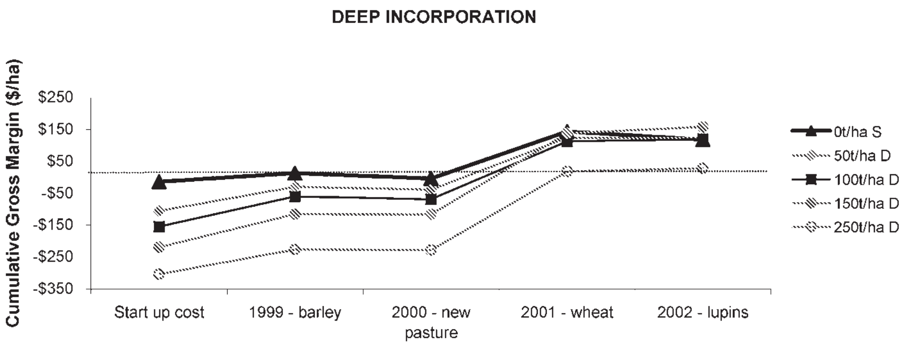

Figure 3: Years to recoup clay spreading expenses from deep incorporated treatments, Wharminda clay spreading trial

What does this mean?

With clay spreading on sands, don't forget that you have changed the nature of your topsoil. If you use a high rate of highly calcareous, high pH clay and don't incorporate it well and deeply into your sand, there is every possibility that you could suffer trace element and phosphorus deficiencies in your crops, due to the nutrient tie-up. There is also the distinct possibility of a lupin crop failure, on country where you have been able to grow lupins in the past. Surface sealing causing poor crop establishment has also been seen in some farmers' paddocks. From a sustainability point of view, despite there being no difference in yield between no clay and 250 t/ha in 2002, there was a big difference in the stability of the soil throughout the season. The 250 t/ha treatments still have a good crust on the soil surface, which protects those areas from wind erosion and consequently protects the plants from suffering as much wind damage of those where no clay has been spread. Striking the happy medium with clay rates such as 150 t/ha is obviously the target though - you get protection from wind erosion, elimination of repellency and improved crop vigour at least cost and effort.

Further monitoring work is required at this site and other clay spread areas throughout the Peninsula before we can establish some clear guidelines on rates to use, types of clays which are best and estimate the realistic long term financial and sustainability benefits.

Acknowledgments

EASTERN EYRE SOIL CONSERVATION BOARD

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- Wharminda Ag Bureau and Ed Hunt for their continued involvement and direction in this work. Jeff & Jodie Jones and John Masters for trial establishment and maintenance and fencing.
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GRDC Grains Research & Development Corporation

Section 8

Section editor: Brendan Frischke

Minnipa Agricultural Centre,
Research Engineer

Tillage

Ask yourself, what would your farm have looked like ten or more years ago with the same rainfall as last year?

In the midst of a national drought, generally EP farmers have had a very successful year. EP yielded about 60 -70% of the 5 year average, even though we had decile 1-3 rainfall. Meanwhile the TV images reminded us of times gone by.

Changes in tillage practice have played a vital role in this success. This is a testament to EP farmers being willing to adopt new technology. Conservation tillage practices have allowed timeliness of seeding and improved water use efficiency. Direct drill methods have reduced soil exposure to wind erosion and maintained flexibility to remove paddocks from cropping rotations at late notice.

Guidance technology (electronic & mechanical) is changing the way operations are implemented in the field. As you will see in this section, significant savings are being made by some EP farmers.

This section will give you information about controlled traffic or tramlining, and the impact of tillage equipment on a whole range of factors including soil throw, compaction, power requirements and seed placement.

With changing methods new problems arise, but with research we will overcome them.

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UNITED GROWER HOLDINGS

Farmer Experiences with Controlled Traffic

EP Farmers - Dean Willmott, Geoff Bammann, Michael Schaefer, Mark & Dianne Fitzgerald, John Masters and Minnipa Agricultural Centre

Samantha Doudle, *SARDI, Minnipa Agricultural Centre*

Key Messages

- **Controlled traffic is being used successfully on Eyre Peninsula.**
- **The main motivation for changing to controlled traffic on EP is to reduce input costs, increase efficiency and ease of management.**
- **There is little knowledge about the impact of soil compaction in Eyre Peninsula soils and hence the overall impact of controlled traffic is uncertain.**

Each year in the EP Farming Systems Summary, we survey farmers who are trying something new or different on a broad scale. This article takes you through the details, bonuses and pitfalls of four farming systems using controlled traffic.

Name: DEAN WILLMOTT	***Property Name:*** MAXVIEW	***Hundred:*** KOONGAWA	
Size (arable): 3,500 ha	***Av area cropped annually:*** 2,300 ha	***Km to nearest town:*** 47 km W of Kimba, 50 km E of Wudinna	
Av annual rainfall: 300-350 mm	***Av growing season rainfall:*** 254 mm	***2002 rainfall:*** 184 mm	
2002 growing season rainfall: 134 mm	***Soil types:*** Mostly red brown loam, some sand, some stone, and some calcareous soil		
Major weeds:	Brome grass on sand, barley grass, rye grass, mustard, turnip, 11 other weeds in smaller numbers		
Why did you change your farming system to controlled traffic?	Mostly for spraying ease and the general efficiency that comes with controlled traffic		
Describe your controlled traffic system	One pass no-till seeding. 40-foot seeder on 9" row spacings with Harrington points, press wheels, coulters. No stubble management. 300 HP 4WD tractor. 2 metre centres.		
Describe your previous operating system	No-till for 7 years. All the same except two tines taken out to form tracks.		
What machinery is most important to have on the same wheel tracks initially?	For us it's a case of suck it and see. Most important in our case was spray wheels.		
Will you have all of your machinery on the same wheel tracks eventually?	Would like to see all winter wheels on tracks but not interested in harvest.		
How do you establish your wheel tracks?	Two tines taken out on 2 m centres		
How do you manage your wheel tracks?	Don't at this stage		
What percentage of your cropping program was, or is proposed for CT:	***2001:*** 0%	***2002:*** 100%, round & round	***2003:*** 90%, up & back
Would you use CT on all of your cropping paddocks, regardless of shape and obstacles?	All paddocks are considered		
What limitations have you encountered with your controlled traffic system?	Different soil types growing different weeds needing different management, all in same paddock.		
Are there advantages of your controlled traffic system over your previous system?	We don't have enough experience yet, except to say I love spraying on the tracks and not having to rely on the blob-dobber.		
Is there any controlled traffic related research you would like to see conducted on Eyre Peninsula?	Yes, is compaction an issue?		
Any other comments?	We aren't CT farmers yet, but are planning to have a proper try from now on.		

Name: **GEOFF & PAUL BAMMANN**	***Property Name:*** **AKERINGA**		***Hundred:*** **YADNARIE & MANN**	
Size (arable): 2,100 ha	***Av area cropped annually:*** 2,100 ha		***Km to nearest town:*** 5 km SW of Cleve	
Av annual rainfall: 360 mm	***Av growing season rainfall:*** 250 mm		***2002 rainfall:*** 250 mm	
2002 growing season rainfall: 180 mm	***Soil types:*** alkaline red sandy loam over clay, heavier red flats, some granite/quartz hills and dune swale country			
Major weeds:	Barley, brome & rye grass, wild oats, medic, mustard & turnip, blanket weed, couch grass.			
Why did you change your farming system to controlled traffic?	Seemed a more efficient way of farming, especially in a continuous cropping program. Reduced compaction. G7reater accuracy/reduced costs. Ease of spraying and seeding.			
Describe your controlled traffic system	12.5 m air seeder, 25 m boom spray (truck mounted), 235 HP JD8300 FWA tractor. Seeder has 305 mm spacing with two 610 mm tracks in centre to match spray truck and front and inner rear tyres of tractor. Air seeder hopper is on 3 m tracks. Tillage is all one-pass no-till, up and back at approx 100 mm depth. Stubble is managed at harvest, ie cut short and spread.			
Describe your previous operating system	Have been no-till, round and round since 1997 so equipment has not changed much.			
What machinery is most important to have on the same wheel tracks initially?	Tractor, boomspray and truck mounted spreader.			
Will you have all of your machinery on the same wheel tracks eventually?	We have no plans to incorporate harvesting operations at this stage.			
How do you establish your wheel tracks?	Marker arms on seeder.			
How do you manage your wheel tracks?	Same as rest of paddock, although we double shoot seed on each side of tracks to use additional moisture from tracks. One track was ripped with a tine to assist truck to stay on line (it's difficult to drive on a ridge).			
What percentage of your cropping program was, or is proposed for CT:	***2001:*** 97% up & back	***2002:*** 100% up & back		***2003:*** 100% up & back
Would you use CT on all of your cropping paddocks, regardless of shape and obstacles?	We use CT on all paddocks, except a couple that are only 3 to 4 ha. The greatest advantage (savings) seems to be in odd shaped blocks, although longer runs without turning are the best.			
What limitations have you encountered with your controlled traffic system?	Single trees are a pain and are weed and snail nurseries. Weeds growing in tracks - mainly the one that has been worked, but not a serious issue. Livestock don't fit in our system (joy!!). Boomspray needs to be three times width of seeder.			
Are there advantages of your controlled traffic system over your previous system?	Less driver fatigue. Don't have to look back at last lap or try to follow foam marker. Sometimes almost impossible to see previous lap in standing stubble or poor Light. Reduced crop damage and less compaction. Ground is more trafficable - mud or sand. Can spray at night. No double spraying/sowing and no missed areas. No need for troughs and fences. There are cost benefits; we seem to cover approx 5 - 10% less area than previously depending on paddock shape. Odd shapes have highest savings.			
Is there any controlled traffic related research you would like to see conducted on Eyre Peninsula?	CT is probably an evolving practice that farmers will adapt to suit their needs and equipment. Maybe the effects of soil compaction under different moisture conditions in our soil types would be worthwhile (ie summer and winter). Is there any point in CT if not either no-tilling or zero-tilling?			
Any other comments?	We are getting a few calls regarding CT and we think that with the increased interest showing in no-till that CT will follow. Farmers are certainly questioning their old practices and changes are certain to occur sooner than we thought possible. Do sheep cause more compaction than wheels?			

Name: MICHAEL SCHAEFER	Property Name: ALTBAK			Hundred: PEELA
Size (arable): 1,350 ha	***Av area cropped annually:*** 1,350 ha			***Km to nearest town:*** 55 km NW of Kimba
Av annual rainfall: 300 mm	***Av growing season rainfall:*** 220 mm			***2002 rainfall:*** 220 mm
2002 growing season rainfall: 188 mm	***Soil types:*** sandy loams, red clay loam over limestone			
Major weeds:	Rye grass, medic, self-sown cereals, Queena, horehound, brome grass, some wild oats			
Why did you change your farming system to controlled traffic?	Input cost control. Minimise compaction. Soil health. Much better for spraying & seeding.			
Describe your controlled traffic system	29 ft Connor Shea Scari Seeder - 7" spacing with Harrington points, Sharman coulters/press wheels. Morris 7180 VRT Aircart. Purchasing 275 HP equal 4WD STX Case. Spray tractor - Fiat 180-90 tractor. Beverly Hydraboom 90 feet.			
Describe your previous operating system	No-till since 1997.			
What machinery is most important to have on the same wheel tracks initially?	Sprayer and tractor.			
Will you have all of your machinery on the same wheel tracks eventually?	Yes, we will have everything on 3 metres.			
How do you establish your wheel tracks?	Tines out on 3 metres.			
How do you manage your wheel tracks?	New boom has tank + 12 volt pump spraying wheel tracks.			
What percentage of your cropping program was, or is proposed for CT:	***2001:*** 60%	***2002:*** 100%	***2003:*** 100%	
Would you use CT on all of your cropping paddocks, regardless of shape and obstacles?	All paddocks are done.			
What limitations have you encountered with your controlled traffic system?	Trees, mostly clumps cause problems.			
Are there advantages of your controlled traffic system over your previous system?	Yes, $10,000 saving on fertiliser. Savings on seed, spray & fuel. Less fatigue spraying & seeding. Sheep have been out since 2000.			
Is there any controlled traffic related research you would like to see conducted on Eyre Peninsula?	Compaction.			
Any other comments?	Difficult to get machinery manufacturers to deal with 3 metre row spacings.			

Dr Nigel Wilhelm, Paul Bammann and Rowan Ramsey in a CT paddock on Akeringa in August 2002

Name: **MARK & DIANNE FITZGERALD**	***Property Name:*** **BENBROOK**	***Hundred:*** **BUTLER**	
Size (arable): 1,150 ha	***Av area cropped annually:*** 850 ha	***Km to nearest town:*** 33 km N of Tumby Bay	
Av annual rainfall: 325 mm	***Av growing season rainfall:*** -	***2002 rainfall:*** 225 mm	
2002 growing season rainfall: 159 mm	***Soil types:*** grey loam with limestone, clay loam with granite, sandy loam with ironstone		
Major weeds:	Rye grass, mustard, capeweed, lincoln weed, wireweed, melons (in descending order of prevalence).		
Why did you change your farming system to controlled traffic?	Initially, due to an on-going interest in the concept. Secondly, for accuracy of paddock coverage and lastly, compaction control. This last one is a pretty hazy reason, as we still have a few sheep and our compaction problem is not as easy to accurately determine.		
Describe your controlled traffic system	Tracks are on 1.8 m centres, 600 mm wide (to match boomspray tractor main tyres). Main tractor is a JD 4440 (160 pto HP), 2WD with lower pressure duals. Airseeder is a Shearer 4150 on 207 mm spacings (12 m wide). Minimum till, full width cut, prickle chain.		
Describe your previous operating system	Everything the same except for 2 tines removed for each track and boomspray. Haven't got the boom organised to 24 m yet, so for CT we cut it back to 12 m and double the jets, so ground speed goes up to 25 - 30 km/hr.		
What machinery is most important to have on the same wheel tracks initially?	Air-seeder tractor and boomspray initially, then airseeder box.		
Will you have all of your machinery on the same wheel tracks eventually?	Harvester probably not - capital cost of 11-12 m harvester out of my league and I don't want to cut back airseeder width.		
How do you establish your wheel tracks?	Marker arms on the end of airseeder, coulter marking lines. All paddocks entering CT for the first time are "pre-marked" (prior to first pass of seeding) in order that at seeding, arms can be removed to simplify seeding.		
How do you manage your wheel tracks?	Not terribly well!! Weeds grow in bare tracks, tracks require shielded sprayer. Didn't organise shielded jets behind 4-wheel bike.		
What percentage of your cropping program was, or is proposed for CT:	***2001:*** 7%	***2002:*** 60%	***2003:*** 100% - too difficult to swap over during the busy seeding schedule
Would you use CT on all of your cropping paddocks, regardless of shape and obstacles?	The alterations between CT and non-CT paddocks take some time, so if a paddock is an awkward shape and cumbersome to work in CT, this may be less than the changeover.		
What limitations have you encountered with your controlled traffic system?	Matching equipment. Accuracy - strange as it may sound, the accuracy that CT enables can also be a problem eg. if you look behind to check the machine (or look up to change tapes...) and look ahead again, it is immediately apparent that you are 6" offline, let alone 1 - 1.5 feet. The accuracy can almost stress you until you relax and accept a margin for human error. Weeds mentioned above. Visibility of tracks after a legume crop is quite a problem, particularly peas, as they collapse over tracks and you end up driving next to the track, instead of on it.		
Are there advantages of your controlled traffic system over your previous system?	CT is great for "greenhorn" farm workers. They don't have to judge distances from previous mark. As the paddock is pre-marked (in my case) we can start/finish/break anywhere in the paddock and not lose our mark. Also quite handy is a cheap GPS, eg. "Boss, there's a skeleton weed in run 27, 100 m from the southern end". Paddocks are on average 10% smaller, coverage of the paddock takes 90% as much seed, fertiliser, fuel, etc.		
Is there any controlled traffic related research you would like to see conducted on Eyre Peninsula?	Basically, the research farmers can't do, ie. compaction at depth (100 - 600 mm) and its economic effects. Linked to this is getting harvest equipment on tracks and whether we need to.		
Any other comments?			

Name: **MINNIPA AG CENTRE**	***Property Name:*** **MINNIPA AG CENTRE** ***Hundred:*** **MINNIPA**
Size (arable): 860 ha	***Av area cropped annually:*** 477 ha ***Km to nearest town:*** 3 km N of Minnipa
Av annual rainfall: 326 mm	***Av growing season rainfall:*** 241 mm ***2002 rainfall:*** 278 mm
2002 growing season rainfall: 219 mm	***Soil types:*** red calcareous sandy loam with granite rises.
Major weeds:	Barley grass, rye-grass, sheep weed, sour sob.
Why did you change your farming system to controlled traffic?	To demonstrate the impact of CT systems on farming operations and subsequent crop performance and soil condition.
Describe your controlled traffic system	Several different systems have been introduced onto the farm, all with no-till (except for broadcast-seeding paddocks) – 1. Conventional. 2. CT with marker arms, round & round 3. CT with marker arms, up & back 4. CT with Beeline auto steer, up & back 5. CT with Beeline auto steer, up & back, wheel tracks seeded Two tines were removed to create each wheel track on 2 m centres.
Describe your previous operating system	No-till, round & round or broadcast seeding, round & round.
What machinery is most important to have on the same wheel tracks initially?	Seeding tractor and boomspray unit.
Will you have all of your machinery on the same wheel tracks eventually?	Yes
How do you establish your wheel tracks?	Marker arms or Beeline auto steer.
How do you manage your wheel tracks?	Left bare or broadcast seeded. No other management.
What percentage of your cropping program was, or is proposed for CT:	***2001:*** 0% ***2002:*** 60% ***2003:*** 60%, some paddocks may always be kept as conventional
Would you use CT on all of your cropping paddocks, regardless of shape and obstacles?	Yes, except for our desire to keep some conventional paddocks for reference.
What limitations have you encountered with your controlled traffic system?	Using marker arms requires long periods of concentration to keep on the mark, reducing opportunities for monitoring equipment Beeline system ran out of satellites for reliable guidance in the afternoons (for short periods) and one paddock was in a shadow for the GPS signal from the base station. A basic oversight in setting up the Beeline system meant that outside rows were seeded on top of each other – this means that these paddocks will have to be re-marked.
Are there advantages of your controlled traffic system over your previous system?	Better operator comfort. No headlands with pinched grain in CT paddocks. Efficiencies seemed best in irregular-shaped paddocks.
Is there any controlled traffic related research you would like to see conducted on Eyre Peninsula?	Extent and severity of soil compaction and its impact on productivity. Determining the best practices for managing wheel tracks.
Any other comments?	♦ Broadcast seeding wheel tracks on Minnipa dirt did establish sufficient wheat to be worthwhile, so we will not bother with that in the future. ♦ Next machinery modification is to get all air seeder cart wheels on 2 m centres, then boomspray unit. We won't bother with header. ♦ We hope that Minnipa soil will pack down hard enough to reduce weeds in the future. ♦ Harvesting down the CT runs much smoother than conventional paddocks. ♦ We thank Minnipa Research Foundation, Beeline Technologies and Haukaas Marker Arms for sponsorship of CT systems on the centre. ♦ The marker arm coulter needed adjustment for extra aggression in stubble paddocks otherwise the mark was hard to follow. ♦ Soil compaction will be monitored on CT and conventional paddocks to estimate its impact on crop productivity and the role of CT in its amelioration.

Minnipa Ag Centre - sowing into standing stubble with Haukaas Marker Arms.

Name: JOHN MASTERS	**Property Name:** MERRIGAL	**Hundred:** VERRAN	
Size (arable): 2,200 ha	**Av area cropped annually:** 1,300 ha	**Km to nearest town:** 40 km SW of Cleve	
Av annual rainfall: 300 mm	**Av growing season rainfall:** 210 mm	**2002 rainfall:** 209 mm	
2002 growing season rainfall: 141 mm	**Soil types:** sand over sodic clay.		
Major weeds:	Brome grass, capeweed.		
Why did you change your farming system to controlled traffic?	To try to reduce inputs and overlaps and double sown areas.		
Describe your controlled traffic system	Instead of working round and round, I work up and back, no-till. Traffic is not "controlled", but headlands are eliminated. Machinery widths and spacings do not match and have not been altered.		
Describe your previous operating system	No-till, going round and round paddocks, leaving headlands.		
What machinery is most important to have on the same wheel tracks initially?	N/A		
Will you have all of your machinery on the same wheel tracks eventually?	N/A		
How do you establish your wheel tracks?	N/A		
How do you manage your wheel tracks?	N/A		
What percentage of your cropping program was, or is proposed for CT:	**2001:** 0%	**2002:** 75%	**2003:** 100% ?
Would you use CT on all of your cropping paddocks, regardless of shape and obstacles?	Yes.		
What limitations have you encountered with your controlled traffic system?	You get a lot less acres done in a day going up and back because you spend 25 seconds out of the ground at the end of each pass. I reverted to "round and round" for the last couple of paddocks and the difference was very noticeable.		
Are there advantages of your controlled traffic system over your previous system?	Overall, paddocks sown compared to previously sown sizes, I averaged 4.5% less area = less seed, super, spray, etc, but slightly more fuel. At $90/ha of inputs = saving of $4.05/ha.		
Is there any controlled traffic related research you would like to see conducted on Eyre Peninsula?	I don't have enough experience to comment here.		
Any other comments?			

Summary

Motivation for changing to controlled traffic

Soil compaction - one of the major motivations for conversion to controlled traffic in the eastern states is to reduce soil compaction from traffic and improve soil structure. On Eyre Peninsula we are somewhat in the dark on the soil compaction issue. I think it would be fairly safe to say that the majority of farmers (and researchers and advisers) wouldn't know if they had a compaction problem and if that problem could be improved with controlled traffic. If you do some snooping around in the soils and tillage archives you can find numerous examples of soil compaction reducing crop productivity under SA conditions. There is definitely scope here for some serious investigation.

Input efficiencies - on Eyre Peninsula it seems the motivation for those who've changed to controlled traffic has largely been increased efficiency and ease of management. These two bonuses alone have been sufficient for these farmers to change, regardless of knowing whether or not a compaction issue exists in their soil. In nearly every case, the farmers appear to be satisfied that they have gained their hoped efficiencies.

Next step on from direct drilling - there is no doubt that controlled traffic follows on very nicely from a direct drilling system. While there is no reason in principle why minimum or conventional tillage cannot be practised in a CT system, there certainly would be some extra hurdles, eg. bringing primary and secondary tillage gear onto the same width.

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Tramline Designs For Better Weed Control

Paul Blackwell, Bindi Webb and Darshan Sharma

Department of Agriculture WA, Geraldton WA

Key Messages

- **In tramlines not used for spraying, seed set of weeds, especially radish, was well controlled with fuzzy or shallow sown tramlines compared to bare tramlines.**
- **Estimated effects of non-spraying tramlines on paddock yield and grain quality were small.**
- **Wyalkatchem was generally poorly adapted and Calingari generally better adapted to tramlines.**
- **The best choices of tramline design will depend more on convenience, weed competition and the need for any early tramline smoothing. Any yield benefits and tramline smoothing from shallow sown tramlines may help compensate for early costs of adoption and rough running.**

Why do the trial?

Use of Tramlines can reduce soil compaction between the tramlines and improve paddock yield by 5-15%. We aimed to optimise the value of tramlines that are not used for in-crop operations. Bare tramlines not used for spraying or spreading can present weed and erosion problems.

Using bare, fuzzy or shallow sown tramline designs in wheat after lupins on a sandy soil, we aimed to quantify:-

1. The relative infestation of weeds that set seed in each tramline design.
2. The grain yield and quality penalties or benefits of each design, each with four wheat varieties.

How was it done?

The trial was near Mullewa on sandy soil in 2002. The different tramline designs were made as follows:-

Bare; two tines were removed for each tramline and the seed from the missing tines sent into the edge rows (the fertiliser was on a separate system and spread across all rows).

Fuzzy; tines modified as for 'Bare', but the seed and fertiliser from the missing rows was sprayed into the tramlines from the hoses strapped to the air-seeder frame above the tramline. The seed was covered by rubber belting dragged in the tramline and rolled by the wheels of the following air-seeder cart.

Sown; the tines were replaced and shallow digging (50 mm) points used instead of 125 mm digging points.

Sown on 8 June with 7.5 m wide air seeder on 300 mm row spacings with seed applied at 80 kg/ha and 74 kg/ha of MAP+ at seeding and a further 80 kg/ha NS21 top dressed at 4 leaves. In-crop herbicides of 500 ml MCPA, 5 g Logran and 4 g Ally with 0.2% wetter were applied on 3 July. May to October rainfall was 150 mm. Plots were harvested as single rows or groups of 4 rows with a plot header.

What happened?

Table 1: Weeds setting seeds, counted in or out of (alongside) the tramlines in November.

Tramline Design	Weeds/m^2				Ratio Of Weeds In :Out Of The Tramline		
	Broadleaved*		Grass#				
	In	Out	In	Out	Broadleaf	Grass	All
Bare	0.28	0.04	0.55	0.13	7.6	4.3	5.9
Fuzzy	0.06	0.04	0.17	0.13	1.5	1.3	1.4
Sown	0.04	0.04	0.20	0.13	1.0	1.6	1.3
LSD (P=0.05)					1.4	1.3	

**mainly radish; # mainly ryegrass*

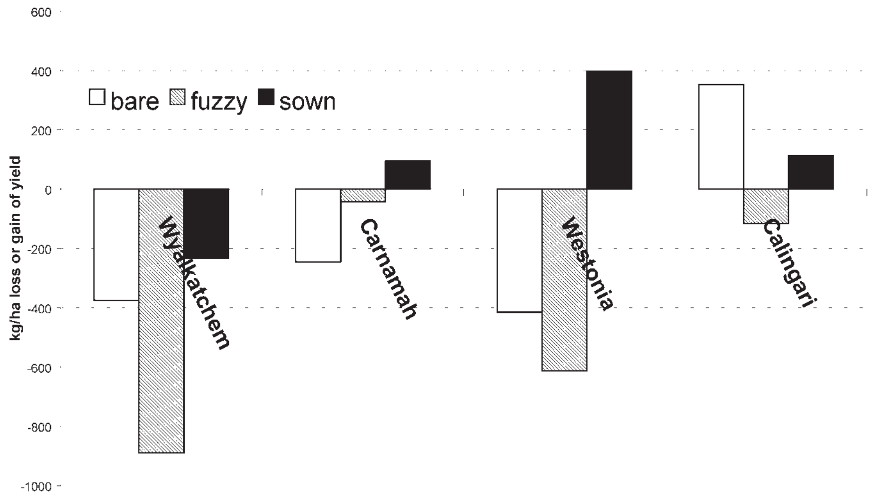

Figure 1: Grain yield loss or gain in the tramline zone (tramline width and both edge rows) for three designs of tramline and four varieties of wheat.

Table 2: Calculated grain yields for the whole paddock (t/ha).

Tramline design	Wyalkatchem	Carnamah	Westonia	Calingiri
BARE	1.65	1.40	1.51	1.45
FUZZY	1.60	1.42	1.50	1.40
SOWN	1.66	1.43	1.57	1.42
"Untrafficked Area"	1.69	1.42	1.54	1.41

What does this mean?

- Bare tramlines had six times more weeds (that set seeds) than the main crop; fuzzy or sown tramlines had no more than the crop (Table 1). More radish than grass was in the bare tramlines.
- The bare tramline zone (tramline and both edge rows) had less yield than the sown tramline zone, except for the longer season variety, Calingiri, which grew 25% more grain (350 kg/ha) in the tramline zone with 50% less screenings than the crop outside the tramline zone.
- Fuzzy tramlines had the poorest yield in the tramline zone, especially Wyalkatchem with a 900 kg/ha penalty but Wyalkatchem still produced the best yield over the whole paddock (Table 2). Carnamah and Calingiri seemed best adapted to fuzzy tramline design.
- Shallow sown tramlines had the most consistent yield benefit in the tramline zone, especially Westonia that increased yield 400 kg/ha. However, rows of crop in the tramline offer no on-ground guidance.
- Most differences in grain quality were too small to change quality over a whole header width- the other rows would easily dilute the effect.
- The effect of design on bulk yield from the whole air-seeder width of 7.5 m is that if sown tramlines are chosen instead of fuzzy to control weeds, a net yield benefit of about 70 kg/ha or 5% of the main crop yield, may be possible with Westonia.

Further information

More detailed information is available in the paper "Tramline Designs For Better Weed Control And Wheat Value From Non-Spraying Tramlines In A Dry Season", Agribusiness Crop Updates 2003, WA Department of Agriculture or by contacting Paul Blackwell, PBlackwell@agric.wa.gov.au, PO Box 110 Geraldton WA 6531, 08 9956 8555 (work), 08 9921 8016 (fax)

Acknowledgments

Mr. Maurice Black and Brian Morris for the trial operations, Kevin Thomas for use of the paddock and to GRDC for financial support of the research (GRDC project, DAW 718).

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Key to symbols

Seeding Depth Still In The Picture

Jack Desbiolles

University of South Australia, Agricultural Machinery Research and Design Centre

Key Messages

- **Many machinery and operating factors affect the uniformity of seeding depth across a paddock.**
- **Research shows that deep sowing beyond 60mm can significantly affect crop emergence and yield.**
- **Many paddock situations can quickly suffer a 5-10% yield loss as a result poor seeding depth, with more extreme situations suggesting possible yield penalties as high as 15-20%.**

Why do the trial?

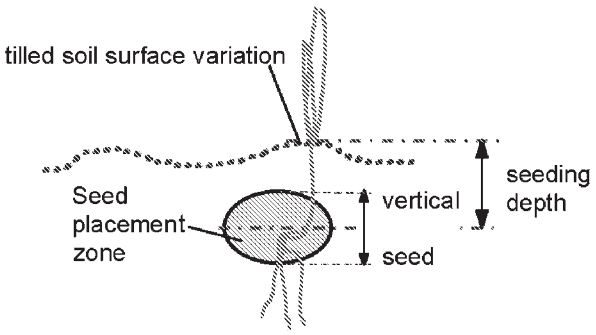
The importance of seeding depth in maximising crop potential is recognised by most farmers. However, being able to quantify the effect of a poorly set and operated seeding machine on crop response is a useful step to justify one's efforts to secure that 'optimum' seeding depth.

In cereals, the coleoptile length influences how accurate seed placement has to be for optimum results. The coleoptile protects the first leaf while pushing through to the soil surface. When sown deeper than coleoptile length, the emergence of the first leaf is at greater risk of failure and disease. Deeper seed placement thus delays emergence (equivalent to sowing later) and reduces the number of emerging seedlings, which may also be weaker and tiller less vigorously. As a general rule, the shorter the coleoptile length of a seed variety, the more accurate the seeding depth needs to be.

Machinery Sources Of Variation

Seeding depth is influenced by both the physical placement of seeds within the furrow and the amount of soil cover subsequently added. Both the vertical seed spread and the uniformity of soil cover will influence the final variation in seeding depth. The seed boot design, setting and matching to point type will dictate the quality of seed placement obtained. But, although critical, its performance is only the first half of the equation, and seed covering is another large source of variation.

A more uniform seeding depth can typically be achieved with press wheels which minimise variation in soil cover, provided they leave a regular and stable furrow profile, at best centred to the seed row. A rougher surface finish such as that achieved by rotary harrows comparatively contributes to increasing the variation in seeding depth.



At the implement level, more significant variation in seeding depth (eg. 20-60 mm) can artificially be created with many seeding systems due to soil throw effects between adjacent rows (ridging issue), whereby front mounted openers get additional soil cover from rear mounted openers. Soil throw typically increases with the square of velocity (ie. it is common to expect soil to reach 4 times as far, at twice the speed). Therefore, soil throw can quickly be controlled with lower travelling speeds and further minimised by low disturbance openers, narrow shanks and wider row spacings. Where individual seed boot adjustment is possible, seed placement can be optimised on a row by row basis to counter or minimise the effects of ridging. Otherwise, levelling out the soil surface after sowing and containing soil throw (eg. rolling shields) are possible options.

In undulating ground, the lack of contour following ability from the machine can create large local variations in both tillage and seeding depth. Flexible frames and a range of contour following design for openers and seed boot systems can provide partially or fully remedial solutions. In soft country and with leaking hydraulic rams, variation in implement sinkage can be monitored and corrected using depth control sensor technology.

How it was done?

Two trials were established last season on a clay-loam site at Minlaton, Yorke Peninsula and on a sandy site at Waikerie, Northern Mallee, using intermediate coleoptile length wheat. Five seeding depths within a range of "too shallow" (10 mm) to "too deep" (110 mm) were implemented in a replicated design, using a low disturbance single shoot opener set at 180 mm row spacings and followed by press-wheels. To eliminate bias, no soil-incorporated herbicides were used at sowing and sowing was conducted at low speed to minimise ridging across rows. DAP Zn @ 110 kg/ha was also deep banded in a separate operation at 110 mm depth.

- At Minlaton, Krichauff wheat was sown on 24 June at 78 kg/ha, targeting 190 plants/m≤ at 95% field emergence. Sowing was conducted in moist soil conditions and significant follow-up rain (50 mm) occurred in 3 events at Day 3, 10 and 20 after sowing. Apr-Oct. GSR rainfall was 266 mm (77 mm below average).

- At Waikerie, Clearfield Janz wheat was sown on 25 May at 64 kg/ha, targeting 140 plants/m≤ at 95% field emergence. Soil conditions at seeding were 15-20 mm drying topsoil and suitable moisture below. 11 mm follow-up rainfall occurred 21 days after seeding. Apr-Oct. GSR rainfall was very low at 91 mm (72 mm below average).

What happened?

Emergence

Figure 1 (top) shows the extent to which wheat emergence was gradually reduced by deeper seeding depth at the Minlaton site, reaching 85%, 73% and 53% of seeding rate, at 60 mm, 85 mm and 110 mm depth respectively. Deeper seeding depth also delayed maximum emergence by up to 6-7 days. An emergence penalty of 12% also occurred at the shallowest seeding depth explained by a proportion of seeds placed in the 0-5 mm depth layer, which did not successfully establish. Under these experimental conditions, wheat established best within the 30-35 mm layer. At tillering, a trend of fewer tillers/plant and smaller plant size with deeper depth was observed.

At Waikerie, a similar response was achieved with slightly lower penalty levels (eg. 89%, 76% and 59% emergence rate at 60, 85 and 110 mm depth), additionally illustrating a situation of staggered emergence at the 10-15 mm depth, due to the drying conditions at sowing coupled with only late follow-up rains. In this case of marginal soil moisture, sowing too shallow resulted in similar effects to delayed sowing (by up to 31/2 weeks).

Yield

At Minlaton, a head count/m≤ conducted prior to harvest showed reduced numbers at and below 80 mm depth of seeding, however, there was some level of compensation at these depths with slightly heavier head weight (8-16%). Harvested yields (Figure 2 - top) showed a large yield drop beyond an optimum depth of 30-40 mm. Deep seeding at 60, 80 and 100 mm created yield penalties of 5%, 13% and 21% respectively, below the maximum yield of 2.55 t/ha. Yield was also decreased slightly (3-4%) at the shallowest sowing depth (10-15 mm). It is anticipated the penalising effects of deeper seeding depth would be greater in above average seasons.

At Waikerie, due to the very dry season (decile 1), the wheat crop yielded very poorly (0.34 t/ha overall) and minimal treatment differences were recorded. Head counts conducted at maturity confirmed a slightly decreasing head density (heads/m≤) with greater depth, but at the 110 mm depth, heads were slightly heavier (20-32%). Yield data showed the lowest yield was obtained at 70-80 mm depth, while the deepest seeding (105-110 mm) achieved an improved yield (8% above average). The Waikerie results are thus biased by the benefits of lower plant densities better suited to the very poor season.

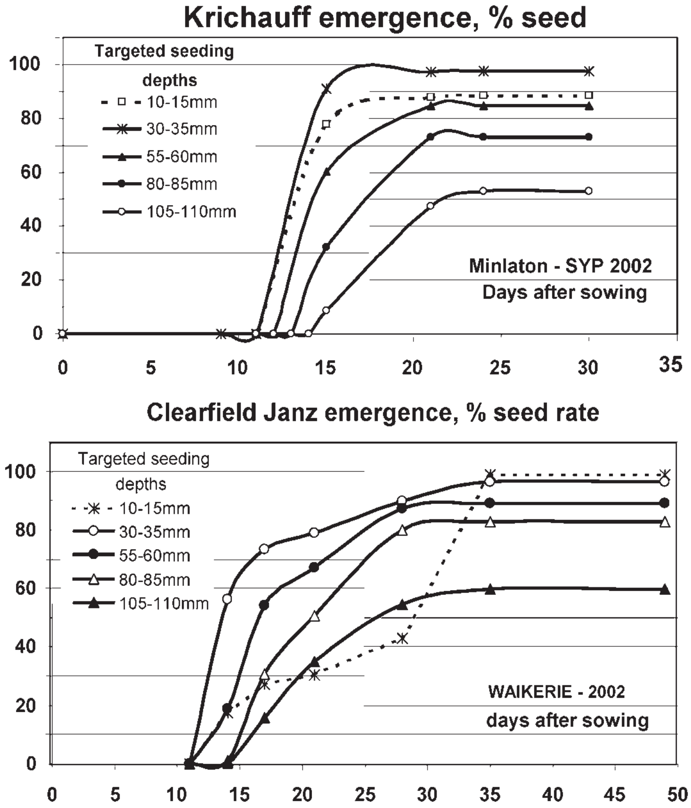


Figure 1: Seeding depth had a drastic effect on crop emergence at Minlaton (top) and Waikerie (bottom).

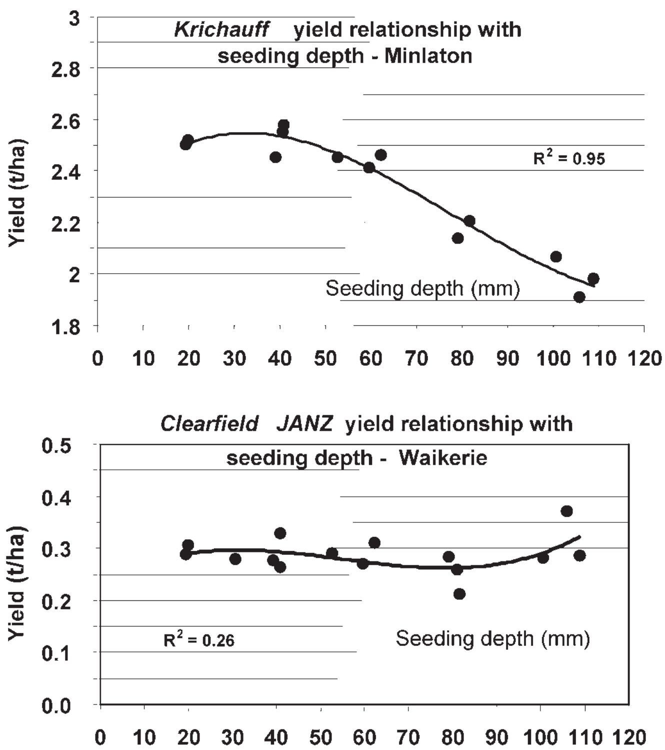


Figure 2: Crop yield potential was seriously compromised by deep seeding at Minlaton (top) but not at Waikerie (bottom) due to the biasing effect of a very poor season.

What does it mean?

The above data reinforces the importance of optimum seeding depth. Assuming the Minlaton yield relationship, the following gives potential yield penalties expectable with poorly set and operated seeding machinery. For a 4 rank implement, with layout exposing 50% tines to double sided ridging (assumed at 30 mm extra soil cover):

- If the optimum seeding depth (35 mm) is achieved, a 3.6% yield penalty is expectable from uncorrected ridging effects.
- If the implement were additionally poorly set to sow at 60 mm depth, an 11.3% yield penalty would be expected.

Seeding depths of 80-100 mm were not uncommon in many surveyed paddocks of Yorke Peninsula and the Mallee, particularly when using levelling harrows and when needing to seek moisture. Farmers need to be conscious of the likely yield loss, and its effect on profitability. Generally speaking, the option of press wheels and deep tillage below the seed zone are useful techniques improving the reliability of crop establishment in moisture limiting conditions, without requiring deep seeding.

Acknowledgments

Research work funded by SAGIT in collaboration with the Southern Yorke Peninsula Alkaline Soils Group and by GRDC as part of the Mallee Sustainable Farming Project. Seeding system equipment provided on-loan by industry manufacturers and importers (details available on request).

Further information

Jack Desbiolles, Agricultural Machinery R&D Centre, UniSA, tel: 08 8302 3946

Seeding Systems And Seed Bed Utilisation

Jack Desbiolles

University of South Australia, Agricultural Machinery Research and Design Centre

Key Points

- **Seed Bed Utilisation (SBU) is an important factor in explaining differences between yields of seeding system trials.**
- **Increasing SBU to 65-70% has increased yields in 3 years of trials in Mallee and Yorke Peninsula soils.**
- **The yield gains relative to an 'average seeding system' have reached 6.6% or 0.15 t/ha.**

Introduction

Seed bed utilisation (SBU) is the proportion of row spacing which is occupied by the crop and/or fertiliser. More land area is available to a given plant population with higher SBU sowing (Figure 1). Several benefits can be expected from high SBU seeding, namely:

- More space per plant promoting less competition between grain producing plants.
- More area covered promoting quicker ground shading, lower surface evaporation and better competitive ability against weeds.
- A greater dilution effect reducing fertiliser toxicity risks.
- Potentially more efficient use of shallow inter-row moisture (eg. small rainfall events).
- Greater buffer against variation in seed rate from row to row due to splitting inaccuracies, delaying high seed rate penalties.
- Enables wider row spacings while minimising plant crowding in the row, for reduced investment cost, lower machine weight and improved residue handling.

Figure 2: Example 2x2" spread paired row (left) and 6-7" spread ribbon (right) seeding technologies.

However, the above potential benefits may come at the cost of:

- Higher soil disturbance required (ie. A move away from the zero-till philosophy), with associated issues of soil throw, stubble clumping, moisture dilution and evaporation at seeding, higher risk of seed/stubble/herbicide contact and greater weed seed stimulation.
- Requirement of wider, heavier and more expensive press-wheel match.
- Lower seeding uniformity typically achieved.

Figure 1: 10-15% SBU seeding (left) versus 65-70% SBU seeding (right).

Higher SBU sowing can be achieved with spreader seed boots, also referred to as splitter, paired row or ribbon banding systems (Figure 2). The following gives indicative SBU levels measured with various seeding technologies (ratings given at 10" row spacing):

- 10% (V seeding disc systems)
- 15-20% (single seed boot outlet close to furrow + narrow opener)
- 25-40% (broader seed boot outlet, higher up above the furrow + wider point/share)
- 30-50%: (well defined paired row systems with narrow points)
- 50-80% (full ribbon sowing, some spreader boots with wide shares)

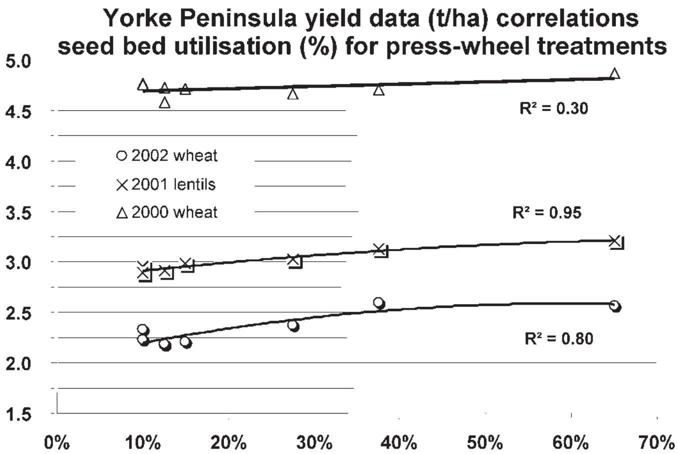
Trial Indications To Date

In direct drill contexts over a range of soil and rainfall conditions, higher seed bed utilisation (ie. 65-70% SBU) has consistently produced above average cereal yields. The technology used has been a double shoot 7” ribbon banding opener with 165 mm wide press wheels. In many cases, this treatment also produced the best yield of the trial, among a range of up to 12 seeding technologies evaluated side by side in replicated trials. Other paired row or wide seed spread technologies (35-50% SBU) used in selected trials have also yielded average to above average.

Figure 3 summarises the relative yield performance of the 65-70% SBU ribbon technology over 3 years of trials in both Mallee sandy soils and Yorke Peninsula clay-loam soils (13 data sets in all). The data sets comprise below average to above average seasonal conditions, on mostly cereal crops. The reference site average yield (ie. Zero line) can be interpreted as the expectable performance of an ‘average’ seeding system, estimated in each trial from the mean of all treatment yields.

A 1.2-13.1% yield benefit (0.03 to 0.28 t/ha range) relative to the trial site average was measured, with an average 6.6% yield gain (0.15 t/ha) above site average. In dry seasons, superior yields were often well correlated to higher seed bed utilisation under both Mallee and Yorke Peninsula conditions (Figure 4 - NB: where the trends were not significant, other interactions such as significant crop establishment penalties had also occurred, attributed to Trifluralin toxicity and seeding depth bias).

The seed bed utilisation apparent response is the strongest machinery trend observed so far in the seeding system trials. In comparison, low SBU double shoot systems (10-20%), such as coulter-disk, 65 mm narrow point and side banding systems have yielded 0.7%, 2.8% and 1.1% below site average, respectively.



optimising crop response, which should not be dissociated from any row spacing and sowing density trials. So far in the Yorke Peninsula trials, the lower performance of coulter disc systems has been in sharp contrast with their largely superior crop start and early vigour achieved. Continuation of this assessment will focus on how to best combine the benefits in seed placement and early crop vigour observed with coulter V discs and the apparent yield advantages of higher SBU sowing.

Acknowledgments

Research work funded by SAGIT in collaboration with the Southern Yorke Peninsula Alkaline Soils Group and by GRDC as part of the Mallee Sustainable Farming Project. Seeding system equipment provided on-loan by industry manufacturers and importers (details available on request).

Further information

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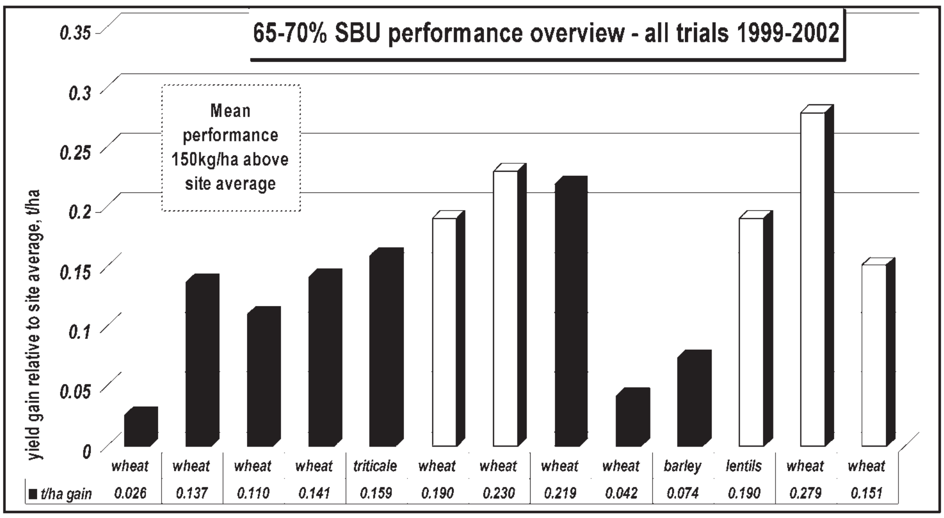

Figure 3: Overview of 65-70% SBU ribbon seeding performance over 13 site-year data sets in Mallee sandy-loam soils (red) and Yorke Peninsula clay-loam soils (yellow).

Section 9

Section editor: Neil 'Fish' Cordon

Extension Agronomist,

Minnipa Agricultural Centre

Weeds

Good weed management is the first step in the chain of factors to achieve potential yields.

Weed management is also an integral part of dealing with HERBICIDE RESISTANCE as it's not "if" but "when" it will be a problem on your farm. As Justin Wundke commented in his survey on this issue, "don't be an ostrich with it's head in the sand". I believe strategic burning, grazing and slashing will have a role in resistance management.

During 2002 the old loyal lincoln weed was present and became the focus of our summer weed work. Farmers have continually identified this weed as the major barrier in allowing them to adopt new farming technology.

Amanda Cook's summary on the effect of herbicides on nodulation of medic and peas really showed the true value of weed control even in a dry season.

REMEMBER: the most costly herbicide and weed management program is the one that doesn't work so put the effort in and be rewarded !

SARDI South Australian Research and Development Institute

United Grower Holdings

2002 Herbicide Resistance Survey

Justin Wundke

Lynch Farm Monitoring

Key Messages

- **Herbicide resistance is an issue on Eyre Peninsula, with both Group A and B resistance found.**
- **Higher intensive farmers are more likely to have herbicide resistance, but resistance was also found in lower intensive systems.**
- **35% of farmers in survey had herbicide resistance; 1/3 of these did not suspect herbicide resistance on their farm.**
- **Still at the lower end of resistance - need to use remaining herbicides shots wisely.**
- **Need to implement Integrated Weed Management techniques, monitor levels and keep records of herbicide use.**
- **Herbicide resistance is here to stay- don't be an ostrich!**

Why do the survey?

To determine the extent of Group A and B herbicide resistance across upper Eyre Peninsula(E.P).

To identify the risk of various farming systems on the level of resistance.

There has been no comprehensive survey done on upper E.P. to identify levels of herbicide resistance.

Herbicide resistance is a real issue already on EP, but the survey will raise it's profile so management strategies can be implemented.

How was the survey done?

70 farmers from across upper Eyre Peninsula with a range of herbicide histories, rainfall and cropping intensity were contacted. As a prerequisite farmers needed to have 10 years of herbicide history. 60 farmers replied, with only 30 having sufficient records and these farmers had two paddocks tested each. Paddock selection did tend towards those with a higher density of ryegrass, suspected resistance or a history of high-risk herbicides. Samples were selected by hand from at least 40 individual plants, densities noted and seed left for one month to overcome dormancy. Chris Preston of CRC for Weed Management tested seeds for resistance to chlorsulfuron (Glean®) and diclofop-methyl (Hoegrass®). Each population had 0.3 g of seed placed onto three separate agar plates. These were:

1. Control
2. Chlorsulfuron (Glean®) treated and
3. Diclofop-methyl (Hoegrass®) treated.

These were wrapped and put in an incubator for one week. A known susceptible population was added for comparison. They were removed and those with green shoots were counted as resistant plants. Populations with more than 20% of plants growing on herbicide were considered resistant; 10-20% as developing resistance. A short questionnaire was also taken to collect herbicide history, farming practices and assess farmer's attitudes and perceptions to herbicide resistance. For the purpose of the survey Group B's were considered to be chlorsulfuron (Glean®) and triasulfuron (Logran®) not metsulfuron-methyl (Ally®). Intensive croppers were considered those at 70% crop intensity (by area) and above.

What did we find?

Of the 60 paddocks sampled, 16 had a Group A herbicide this year and 11 had a Group B herbicide.

Not all samples had sufficiently broken their dormancy. Further testing will be conducted on these. 53 out of 60 had sufficient germination and results within this report are from this preliminary testing.

Out of 53 populations, 12 were found to have Group B resistance (23%), while 5 populations (9%) had Group A resistance.

A further 5 populations were found to be developing resistance to Group A herbicides and 3 populations to Group B herbicides.

Table 1: Preliminary results of herbicide resistance survey on 53 ryegrass populations on upper EP for Group A & B herbicides

HERBICIDE TYPE	CROPPING TYPE	RESISTANT	DEVELOPING RESISTANCE	SUSCEPTIBLE
Group A	Intensive	4	2	20
	Lower intensity	1	3	23
	Total	5 (9%)	5 (9%)	43 (82%)
Group B	Intensive	8	0	18
	Lower intensity	4	3	20
	Total	12 (23%)	3 (6%)	38 (71%)

Some populations had one or two definite resistant plants in the test but were not classified as resistant or developing resistance as there were below 10%. This indicates that there is still resistance in the population that will increase when selection pressure from Group A and B herbicides is applied.

Of the resistant populations, only one had resistance to both Group A and B's. It had only one Group B in the past 11 years and may be a case of cross resistance (resistance developing without even being exposed to a herbicide group due to resistance to an alternative herbicide group).

Group A resistant populations had an average of 4.75 applications (range 4-9); Group B resistant populations had an average 4.5 applications (range 1-8 applications). It has to be noted that the resistant population with one Group B application had 9 Group A's applied and is very likely to be due to cross resistance.

Only 2 farmers (out of 30) listed ryegrass as their worst weed. 20 listed it as a major weed, with 8 as a minor weed (2 of these had confirmed Group B resistance). This probably indicates these farmers have achieved good control of ryegrass with herbicides in the past.

Four of the farmers had already confirmed resistance on their farms and eleven suspected resistance (most farmers first suspected resistance in the past 3 years). 15 (50%) did not suspect resistance on their farm.

Of the eleven farmers with resistance, 3 had confirmed resistance earlier, 4 suspected resistance earlier while 4 did not suspect resistance. See table 2 below.

Table 2 : Results of four farmers without suspicion of resistance

RESISTANCE TYPE	RESISTANCE %	NUMBER OF APPLICATIONS
Group B	41%	4
Group A	42%	6
Group B (2 paddocks)	50%	4
Group B	31%	5

Six of the eleven farmers with resistance listed herbicide resistance as a future issue - only five had it as a current issue. The majority of the farmers in the survey (83%) will check on the mortality of ryegrass after a Group A or B application. Group B resistance was found in one sample to be 100% (no kill when chlorsulfuron applied) and in Group A, one population had 64% resistance (only one in three plants are controlled by diclofop-methyl).

What does this mean?

Herbicide resistance was found across all of upper EP. Higher intensity croppers tended to have more resistance than lower intensity farmers. Lower intensity farmers can still have high levels of resistance though (populations with 67% Group B and 40% Group A were found).

A number of samples showed up individuals with resistance but the whole population was not resistant. This indicates that there are a couple of "hits" of high risk herbicides left before full scale resistance occurs. These need to be rotated and used wisely along with other reduction strategies (Integrated Weed Management).

We are in a position where we can learn from other farmers/districts who were in the same position 5-10 years ago.

Levels of resistance in this survey may actually be lower than commercial tests, as the samples were collected at random across paddocks whereas often farmers test on patches which may be a "hotspot" of developing resistance.

It is concerning that one third of farmers found with resistance did not suspect it on their farm. We need to change our perceptions and attitudes, to address a developing problem.

You need to check paddocks after an application of a high risk chemicals, to help identify herbicide resistance sooner and to take preventative action.

Accurate records were not kept by half of farmers initially approached. This is of great importance in determining paddocks at risk of developing resistance. A rule of thumb is that paddocks with 4 applications of a pre-emergent Group B or 7 Group A's are at high risk of developing herbicide resistance. Note that it can be less than that (a local resistant population was found after just 2 Group A applications).

If ever in doubt of a spray result, get a test taken to identify if you have resistance. The first step to dealing with a problem is to identify it (no use being an ostrich - herbicide resistance is here to stay).

Acknowledgements

EP Farming Systems Projects

Chris Preston, CRC for Weed Management

Farmers who participated in the survey

GRDC Grains Research & Development Corporation

SARDI SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

Herbicide Effects on Nitrogen Fixation in Legumes

***Amanda Cook*[1] *, Ian Creeper*[2]*, and Annie McNeill*[3]**

[1] SARDI, Minnipa Agricultural Centre, [2] formerly SARDI, Minnipa Agricultural Centre,
[3] Adelaide University.

Location:
Minnipa Agricultural Centre
Seed Paddock - Section 4

Rainfall:
Av. annual: 326 mm
Av. G.S.R.: 241 mm
2002 total: 278 mm
2002 G.S.R.: 219mm

Paddock History
2002: Peas
2001: Grass Free Pasture
2000: Grass Free Pasture
1999: Wheat

Soil Type
Sandy loam, pH 8.9
Plot size
10m x 1.44m x 4 Reps.

Key Messages

- **Herbicides slightly delayed the activation of nodules in medic, but peas showed little difference in nodulation.**
- **Weed control should not be compromised, as this was the major factor influencing overall yield.**
- **The influence of herbicide rate, timing and application techniques has a greater effect on medic and pea production than nitrogen fixation.**

Why do the trial?

In the low rainfall region of the Murray Mallee, a number of herbicides recommended for use in legumes (vetch and peas) have been found to reduce the number of nodules per plant and N2 fixation. Herbicides are a vital component within current farming systems and are commonly used in medic pastures and legume crops to control weeds. Herbicides used to control problem broadleaf weeds in medic-based pastures can often result in reduced herbage production. Since one of the major benefits from legumes is the N input to the system it is important to determine if broadleaf or grass selective (group A) herbicide applications reduce N2 fixation. Trials were conducted at Minnipa to determine the effect of commonly used herbicides on nodulation and N2 fixation in medic and peas.

How was it done?

Replicated plots of strand medic (Herald) and Parafield peas (fertilised with 18:20 @ 70 kg/ha) were sown on 7th June 2002. Pre-sowing herbicides (Table 1) were applied 1 hour before sowing. Early post emergent herbicides (Table 1) were applied 5 weeks later on the 16th July when the medic had two-true leaves and the peas were at the 5-node growth stage. Conditions at spraying were overcast with a southerly wind blowing at 10 km/hour. Herbicides were applied using a 2 m shrouded boom with TeeJet® 11002 nozzles at a pressure of 30 psi. Water volume was 50 L/ha pre-

Table 1: Herbicide treatments applied to Medic and Peas.

CROP	TIMING	HERBICIDE	RATE + ADDITIVES
HERALD MEDIC	Early post emergent	Broadstrike®	25 g/ha + BS1000 100 mL/100L
		2,4 D Ester	100 mL/ha
		Fusilade®	400 mL/ha
		MCPA Amine	350 mL/ha
		Targa®	250 mL /ha + BS1000 100 mL /100L + DC-trate 1 L/100L
		Tigrex®	100 mL/ha
		Verdict 130®	400 mL/ha + Uptake oil 200 mL/100L
PARAFIELD PEAS	Pre-sowing	Trifluralin 480®	1.2 L/ha
		Trifluralin 480® +Glyphosate +Diuron®	800 mL/ha 1 L/ha 1 L/ha
	Post-sowing/Pre-emergent	Lexone®	180 g/ha
	Early-post emergent	Broadstrike®	25 g/ha + BS1000 100 mL/100L
		Diuron® +MCPA Sodium	1 L/ha 800 mL/ha
		Brodal ® +MCPA Amine	125 mL/ha 125 mL/ha
	Early-post emergent	Verdict®	130 400 mL/ha + Uptake oil 200 mL/100L
		Targa®	250 mL/ha + BS1000 100 mL/100L + DC-trate 1 L/100L
	Late post emergent	Diuron® +MCPA Sodium	1L/ha 800 mL/ha

sowing and 70 L/ha post sowing. Lexone® was applied post-sowing /pre-emergent on 9th June, and diuron+MCPA sodium late post-emergent, eight weeks after sowing, on 5th August (Table 1).

Shoot dry matter was sampled and plants roots were assessed for number and appearance of nodules 14 and 35 days after each herbicide application. The scoring system used for nodules ranged from zero, which indicated poor nodulation to a maximum of five, which corresponded to excellent nodulation. The colour of the nodules was noted because this can be related to function (Table 2).

What Happened?

Medic

Several of the herbicide applications, 2,4-D Ester, MCPA Amine and Broadstrike®, had reduced early shoot growth by 14 days after application (Figure 1). Tigrex® caused leaf discolouration but did not reduce dry matter. At this stage there were no differences in nodule score between treatments, and averaged 3.9. However, nodules on plants from the MCPA Amine, 2,4-D Ester and Tigrex treatments were white and therefore non-functioning (Table 2), compared to effective pink nodules in the other treatments and the control.

Table 2: Nodule colour and function

COLOUR OF NODULES	FUNCTION
White	Healthy but non-functioning: therefore not fixing and probably never have been
Pink	Healthy and functional, therefore fixing
Green	Senescent nodules, therefore were functional at some time but now are not and the pink pigment has gone off.

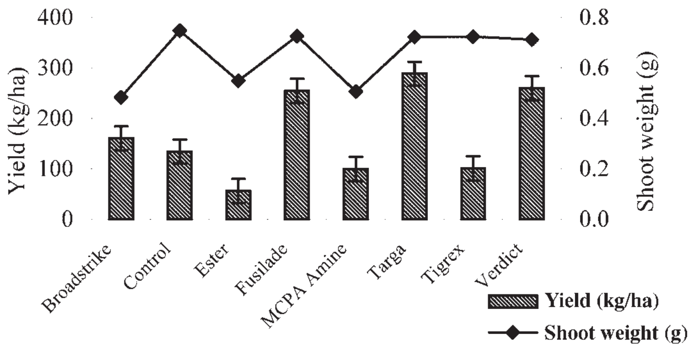

Figure 1: The effects of herbicide treatments14 days after herbicide application on seed yield and shoot weight of Herald Medic at Minnipa in 2002.

The most likely explanation for the observed white nodules on the medic roots that received group I herbicides is that at the time of spraying, the medic was still growing on seed N so the roots had either not formed nodules or had very few but non-functional nodules. The herbicide application temporarily affected the shoots, restricted photosynthesis which provides the energy for nodules, and thus the time period for the nodules to become healthy and functional was extended. When the roots were scored at 35 days after spraying nodules were healthy, indicating that the herbicide effect is relatively transient and had apparently been overcome. Plants in all treatments had pink healthy functional nodules 35 days after application and averaged 3.9 for the whole trial.

The medic trial was hand harvested on the 11th December, cleaned and threshed. The treatments with lower seed yield (Figure 1) corresponded with those that had lower shoot weights 14 days after herbicide application, although, apart from the 2,4 D Ester treatment yields were not less than the control. The main reason for the low seed yields was the higher grass weed competition in these treatments and the control compared to those treatments with few weeds (Fusilade®, Targa® and Verdict®) which had higher seed yields (Figure 1).

Peas

Broadstrike® and Diuron MCPA herbicides caused visual differences in plant growth that corresponded with trends in shoot dry weights. Nodulation was at adequate levels on all pea plants at 14 days after herbicide application although some treatments appeared to have fewer nodules on the lateral roots. At 35 days there were no differences in the number of nodules, and many new small nodules were being developed in all treatments. The Diuron MCPA Sodium (late treatment) was examined 56 days after the first treatments were applied, and these plants were suffering severe drought stress, hence some nodules were turning green.

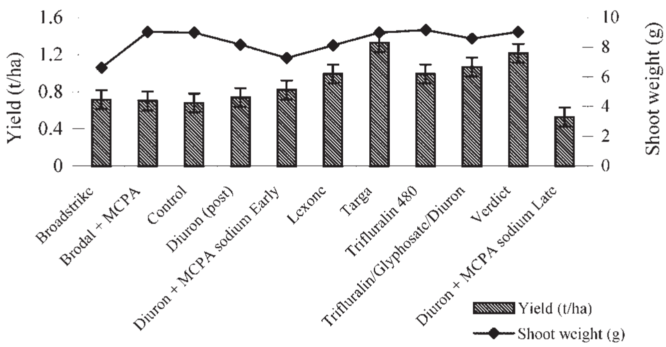

Figure 2: The effect of herbicide treatments 14 days after herbicide application on grain yield and shoot weight of Parafield Peas at Minnipa in 2002.

The trial was harvested on 29th October and like the medic those plots with better grass weed control, Targa® and Verdict®, yielded well. The Diuron MCPA Sodium (late treatment) was sprayed fourteen days later than the early post emergent treatments and had the poorest weed control and lowest grain yield.

What does this mean?

Application of the herbicides Broadstrike®, 2,4 D Ester and MCPA Amine reduced shoot growth in Herald medic within 2 weeks of application and caused a delay in the development and activation of nitrogen fixing nodules. However, by five weeks after herbicide application functional nodules were regained. Shoot growth in Parafield peas was also slightly reduced by early post-emergent applications of Broadstrike and Diuron + MCPA Sodium but the number of nodules per plant and apparent nodule function were not reduced. Nevertheless, it is possible that the set-back to legume development during this critical three week period allowed a stronger weed base to germinate and develop resulting in medic seed yield and pea grain yields similar to the untreated control. Overall, the yield results from this trial indicate that weed control is essential for maximising seed and grain production by legumes in this environment. It is also clear that the herbicides that gave the best weed control in this particular situation were also the ones that did not adversely affect the legumes at application.

It is not yet clear why some herbicides upset N fixation in trials in the Murray Mallee during 2001, but different results were observed at Minnipa in 2002. Although there is a risk to N fixation with the use of these herbicides, poor weed control is a much bigger risk to the farming system. More information needs to be provided by detailed trials before these two risks can be balanced.

Acknowledgements

This trial was part of the Eyre Peninsula Herbicide Diagnostic Field Day sponsored by Nufarm, and in particular support from Ken Webber was greatly appreciated.

This work was funded by GRDC, SARDI and SAGIT and would have not been possible without the assistance of Willy Schoobridge and Lisa Bennie, MAC.

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SAGIT

Minnipa Research Foundation

Best practice	Try this yourself now	Almost ready	Searching for answers	Searching for problems

Key to symbols

Is summer weed control worthwhile on Eyre Peninsula ?

Neil Cordon and Samantha Doudle

SARDI , Minnipa Agricultural Centre

Key Messages Box

- **Economic yield increases are possible by controlling summer weeds provided they are sprayed at the right time, using the correct rate and herbicide , high water rates and some common sense.**
- **The best summer spraying time for Lincoln Weed is at 20 % flowering after the summer rain.**

Why do the trial?

Trials were set up to investigate the impact of various methods and timings of summer weed control on yield and profit.

Summer weed control research began at four sites across Eyre Peninsula in 2000 (EPFS Summary 2000, pg 128). 2002 was the second year that summer weed research has been possible, due obviously to lack of summer rain in the intervening years. Heavy rainfall in some areas during harvest of 2001 encouraged summer weeds to grow rapidly. However the summer and autumn of 2002 proved to be the driest on record in many areas which controlled the summer weeds naturally! As a consequence only the early treatments were applied from a program that originally included various timings as well as chemicals and rates.

This series of trials compliments a similar program in the Mallee of South Australia, Victoria and New South Wales and aims to provide producers with a decision support framework to enable the adoption of cost-effective summer weed management programs.

Many farmers on U.E.P. have identified that Lincoln Weed (in particular) is a major barrier to the adoption of some of the latest farming techniques.

Table 1: Weed control methods and treatment costs used at Elliston and Piednippie, 2002

Treatment	Treatment Cost ($/ha)
Complete 1. metsulfuron methyl @ 5 g/ha + wetter 2. Glyphosate @ 0.4 L/ha + Ester @ 0.2 L/ha + wetter	13.51
metsulfuron methyl @ 5 g/ha + wetter	1.81
metsulfuron @ 3 g/ha + MCPA @ 0.3 L/ha	3.24
MCPA Amine @ 1.5 L/ha+ LI700	8.75
24-D Amine @ 2.2 L/ha + Glyphosate @ 0.8 L/ha	17.83
Nil/Control	0

How was it done?

Only two sites from the original four, Elliston and Piednippie, contained summer weeds in 2001 and hence the early treatments were applied (Table 1). Lincoln weed was the main weed present at both sites. The early chemical treatments were applied on 8 th of November 01. This was the only chemical application for all treatments except complete, which was sprayed again on the 6 th of February 02 in order to maintain zero weed growth.

Elliston was sown to Krichauff and Piednippie to Excalibur. Rain water was used at 70 L/ha through a covered boom.

Plant counts were taken in February 02 and harvest yields.

What happened?

At both sites the nil treatment was significantly lower yielding than any of the spray treatments and had the lowest gross margins (Table 2). The complete or double whammy approach had the highest yields and gross margins at both sites. Lincoln Weed growth whilst not prolific, was still sufficient enough in number to warrant control measures.

What does this mean?

This trial shows the importance of controlling Lincoln weed over the summer period even in years with low summer rainfall. There appears to be little yield difference between the various herbicides with input cost per hectare important but

Location
Elliston
Nigel May
Elliston Farmers

Rainfall
Av. Annual : 410 mm
Av.G.S.R : 340 mm
2002 total: 315 mm
2002 G.S.R: 272 mm

Yield
Potential: (W) 3.2 t/ha
Sowing Date : 10/6/02
Sowing Rate : 65 kg/ha
Fertiliser : 18: 20:00 @ 50 kg/ha

Paddock History
2001: Pasture
2000: Wheat
1999: Pasture

Soil Type
Grey calcareous sand

Diseases
Rhizoctonia

Plot size
12m x 1.38 m x 4 reps

Other factors
Snails, Brome grass, Sowing time

Location
Streaky Bay
Howard Feltus

Rainfall
Av. Annual : 350 mm
Av. G.S.R : 309 mm
2002 total: 266 mm
2002 G.S.R : 225 mm

Yield
Potential: (W) 2.3 t/ha
Sowing Date : 3/6/02
Sowing Rate : 60 kg/ha
Fertiliser : 17:19:00 Zn 2.5 % @ 75 kg/ha

Paddock History
2001: Pasture
2000: Wheat
1999: Pasture

Soil Type
Calcareous sandy loam

Plot size
10m x 1.6 m x 4 reps

Other factors
Delayed sowing, Dry conditions

Table 2: Yield and gross margin of summer weed control treatments at Elliston and Piednippie, 2002

Treatment	Elliston			Piednippie		
	Weed Counts 1/10th m 2	Yield (t/ha)	Gross Margin ($/ha)	Weed Counts 1/10th m 2	Yield (t/ha)	Gross Margin ($/ha)
Complete	0.7	0.79	125.96	0	0.70	87.87
5g metsulfuron methyl (early)	3.7	0.73	121.63	0	0.64	84.95
3g metsulfuron + MCPA (early)	4.5	0.67	104.89	0	0.62	77.86
MCPA + LI700 (early)	1.2	0.66	99.53	0	0.65	80.58
24-D Amine + Glyphosate (early)	2.2	0.64	84.87	1.7	0.68	77.70
Nil/Control	4.5	0.54	79.20	1.5	0.58	71.45
LSD (P≤ 0.05)		0.01			0.08	

they should not over ride other considerations like plant back periods and crop rotations.

Spray timing is vital, for example, treatment of Lincoln weed is more effective if plants are sprayed at 20% flowering rather than immediately after germination. Other summer weeds are best tackled whilst still small.

At this stage the jury is still out on the most effective herbicide and rate which most probably will vary from year to year. The EPFS project is continuing to evaluate a range of summer weed issues in 2003 to hopefully fine tune some of the unanswered questions.

Was the yield increase due to competition with the crop during the 2002 season or a moisture conservation factor over the summer months? Well in the Murray Mallee, Fromm and Grieger found that by the end of summer the top 30 cm is usually dry, regardless of what summer weed treatment was applied. Moisture losses are due to plant growth, evaporation or a combination of both. Increased yield in the following crop can only occur if the crop roots can access stored moisture below 30 cm. I would bet on the combination of both.

Acknowledgments

Nufarm, E.P. Soil Boards, E.P. Community Landcare, Advisory Board of Agriculture, GRDC, SARDI.

We also thank the co-operators for their time and provision of trial sites and the leg work of Wade Shepperd from Minnipa.

Weed Wiper vs Boom Spray

A small demonstration of a weed wiper compared to a boom spray was conducted at Elliston next to the replicated trial. The weed wiper is being used to wipe chemical on weeds that are higher than the crop as a technique to control weeds that may have developed resistance, eg Ryegrass in lentil or pea crops. Metsulturan methyl @ 5 g/ha was applied on the 6th February 02 to Lincoln weed. The yields are shown in TABLE 3.

Table 3:Wheat yields of Weed Wiper Vs Boom Spray

Treatment	Yield (t/ha)
Weed Wiper	0.75
Boom	1.15
Nil	0.51

Results

From this demonstration the boom spray yielded 56% better than the nil and 36% above the weed wiper. These yield differences were quite visual and suggest the boom was more effective in delivering the herbicide to its target. Could it be canopy penetration?

It is interesting to note that the same treatment applied on the 8th November 01, only yielded 0.73 t/ha compared to 1.15 t/ha in this demo. Obviously timing is important but it was probably luck more than good management.

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Eyre Peninsula Soil Boards

Mechanical Stimulation for Couch Grass Control

Iggy Honan,

(Cleve) Eastern Eyre Animal & Plant Control Board

Location
Tuckey
Bill & Melinda Herde
Arno Bay Ag Bureau

Rainfall
Actual annual total: 282 mm
Actual growing season: 195 mm

Yield
Potential: 1.7 t/ha
Actual: 1.4 t/ha

Paddock History
2001: pasture
2000: barley
1999: pasture

Soil Type
white siliceous sand

Plot size
10mx50m x 4 reps

Key Messages Box

- **Pre ripping or cultivation of Couch Grass (Cynodon dactylon) can aid in subsequent chemical success but is a minor factor in the overall success. Other management factors such as rate of herbicide application, timing and plant health would be far more important.**
- **While it was not the intention of the trial, it did demonstrate that deep ripping of sand could increase yields by 30%.**

Why do the trial?

The trial was conducted to see if Couch could be stimulated into more chemical uptake and getting a more complete kill of patches. A number of chemical trials had previously shown that there was a reasonable return in cropping land when Couch was treated with at least 2 L/ha of Glyphosate. Generally this only lasted one or 2 years where the infestations were well established. It was thought that by stimulating the plant and then waiting for it to flourish, better chemical controls could be achieved. The differing mechanical options were a result of discussion with members of the Arno Bay Ag Bureau and the availability of machinery in the district.

How was it done?

While the trial was partly funded with a grant from the SA Ag Bureau and was intended to be conducted at Arno Bay, finding a suitable site became impossible and the site was moved to Tuckey. An homogenous patch of couch was selected on the side of a gently sloping sand rise with the intention of cultivating before harvest and spraying when summer rains would allow.

The plots were treated mechanically with implements on November 7, 2001 after a 5mm rain. The plots were quite prone to erosion except the deep ripped, which was very lumpy due to the Couch wrapping around the tynes and creating furrows (this could be avoided with the addition of coulters). Summer conditions were very hot and no rain fell until late January 2002. Within 10 days we sprayed across the cultivation plots with 2 and 4 L/ha of Glyphosate. Prior to this the couch looked very sick and not suitable for a great result.

A wheat crop of Westonia was subsequently sown on the July 1, 2002 being the last paddock sown with conditions being reasonable. Using min-till with an air-seeder is the general sowing method plus trifluralin and Glyphosate applied at seeding. The paddock has normally been sown to barley due to its sandiness.

The 2 L/ha treatment may have been at a disadvantage since it was near the top of the sand rise. It was shown that yields would generally improve as you moved down the sand rise.

What happened?

There are really two things that this trial showed.

1) Controlling couch grass is profitable using chemicals.

2) Deep ripping sand will increase yields (in this case 30%) but other methods could be variable.

This trial proves yet again that couch, a deep-rooted perennial, will drastically reduce grain yield. The gain from the mechanical disturbance alone is significant, however the combination of mechanical disturbance and chemicals would only be economical if the you were trying to manage patches of the weed, not broad scale areas.

Glyphosate @ 2 L/ha, sprayed under poor conditions, gave what I would term an unacceptable result, from the point of view of couch regrowth this year. However, this rate still gave a very profitable return, particularly given that this particular treatment was on the poorer side of the nil plots on the sand rise.

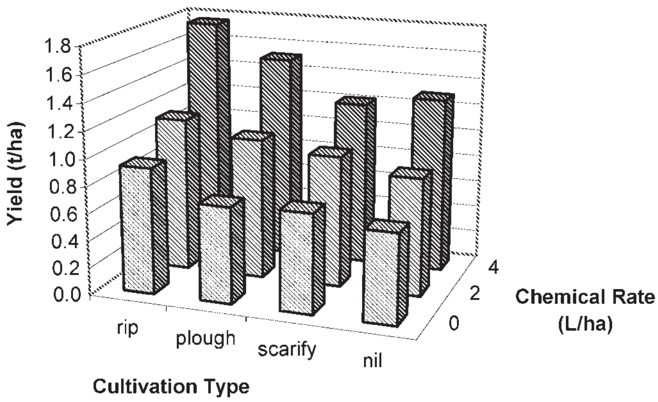

Figure 1: Wheat yields 2002 at Tuckey with mechanical and Glyphosate treatments

What does this mean?

A program to kill couch grass is vital to achieve increased yields. Where practical, combine tillage with chemical applications, bearing in mind wind erosion risks.

The recommended message is really no different than before, other than it does outline the fact that the more fresh top-growth these plants have, the more likely we are to get better and deeper translocation of chemicals.

The way is also open for tillage to follow up any regrowth and this might even be done in early May if erosion was an issue. This third whammy on an already weakened plant followed by a vigorous competitive crop could possibly spell the end to many areas of couch.

While not really fitting in with the no-till principal, there is a need for some cultivation. However given that couch grass is usually in small well established patches they often need separate management anyway.

Acknowledgments

I would like to thank Bill and Melinda Herde for the site and cooperation, Wogga Mills for the deep ripper, Ian Burton for the scarifier, Nigel Crosby for the Plough and the Arno Bay Ag Bureau for their keen interest.

Native Nightshades - Tough Nuts to Crack

Iggy Honan,

(Cleve) Eastern Eyre Animal & Plant Control Board

Key Messages Box

- **Make sure you have any new plant on your property correctly identified.**
- **Keep native nightshade off your property and heavily spot spray new outbreaks.**
- **Ensure that any new stock introduced are either penned for 10+ days or are from clean areas.**
- **Ideal conditions for treating nightshades broadacre are when plants are flowering with cool weather.**
- **Spot spraying new patches with Picloram products will give best success but Glyphosate is also suitable on new outbreaks.**

Why do the trials?

The trials were conducted to ascertain whether we could kill three native Nightshades that are rapidly spreading through cropping land on Eastern Eyre Peninsula (EEP).

Some small plot trials and farmer observations indicate that these natives 'gone wild' could be reducing crop yield by 10-60%.

Previous trials indicated that these plants were very tough to kill.

Observations about the spread of the plants and their root systems have also been carried out.

Two regional farmer groups have been formed, one to look at Rock Nightshade and the other Afghan nightshade.

Background

The two main plants being looked at are:-

1. **Afghan** Nightshade - *Solanum hystrix*

This prostrate prickly native appears to be associated with white siliceous sands that are slightly acidic. It can be spread by root fragments under ideal moisture conditions, but it is felt that most spread occurs when seed passes through stock. We have observed plants growing from fragments in the Kelly area and we have collected sheep dung which was loaded with viable seed.

2. **Rock** nightshade - *Solanum petrophilium*

Another prickly upright bush that can be quite woody appears to be found near granite outcrops but appears to also occur on areas where there may be alluvial granite. On Eastern Eyre this mainly occurs north of Cowell and in the Buckleboo area. We found no field evidence of root fragment growth but were able to do this in the laboratory. Spread seems likely to be from seed through stock as some properties adjacent to infested have no evidence of the plant.

* The other native that appears right throughout the area is Quena - Solaum esuriale

In poorer sandy or gravely soils this plant can be very competitive but in heavier soils it has less effect. We have not been able to determine spread mechanisms and in many cases farmers have seen the plant occur in the same patches for decades.

What happened?

Previous trials indicated that glyphosate and phenoxy chemicals were the most promising.

Last year we also tried some more residual chemicals such as fluroxypyr (Starane®) and picloram (Tordon®).

The other interest was that Glyphosate mixed with 2,4-D amine showed real promise, but we also knew that the two chemicals antagonised each other after some 20 minutes.

The trials were spread over EEP, including Afghan at Kelly, Quena at Midgee and Rock at Mitchelville.

The trials did not bring any magic fixes and although in many cases the top growth was completely killed, regrowth appeared in varying amounts. As the Afghan nightshade is so smooth and waxy it is very difficult to penetrate but its very soft roots in the top layer appear to be burnt off after chemical application leaving the tougher lower roots. The Rock nightshade always tends to look sick with its rusty leaves and woody stems, as it appears to withstand chemicals in much the same way it deals with 40-degree days. Quena is a real tough nut and in one trial it showed little damage after 4 L/ha of Glyphosate was sprayed over it!

What does this mean?

Farmers who don't have these plants must take great care when purchasing or moving stock.

Small new outbreaks should be identified correctly and then spot sprayed vigorously.

We will further investigate the split application scenario of amine and Glyphosate.

We did prove by premixing the above chemicals and then applying them after one hour that they become 50% or more less effective.

We will carry out some research on wetters/penetrants to see if we can increase the effectiveness of chemicals.

Acknowledgements

I would like to acknowledge the work done by my colleagues John Charlton and Kylie Evans. Thanks to Bert Woolford,

David Franklin, John Schultz for trial sites and the members of the nightshade Committees.

Notes

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Key to symbols

Section

10

Section editor: Jim Egan,

Senior Research Agronomist,

SARDI, Port Lincoln

Risk Management

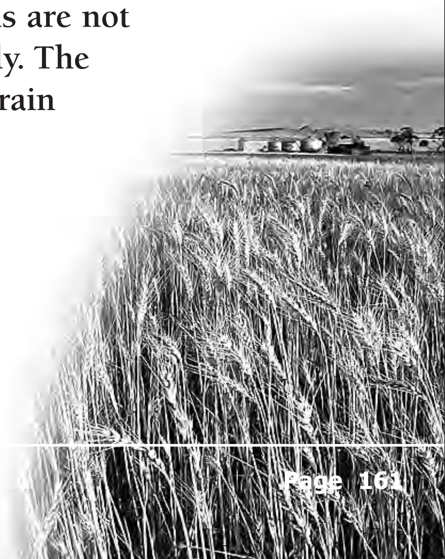
"Farming is a risky business".

Certainly not an original statement, but the truth of it was resoundingly reinforced by events of 2002.

While El Niño returned drought conditions of record proportions to many parts of Australia in 2002, the Eyre Peninsula was mostly spared the worst of this. A major factor in the EP achieving reasonable crop and pasture production in 2002 was our favourable first half to the season, before the spreading El Niño influence finally reached us around August.

Reports in this section discuss how farmers are managing the effects of such climatic risks on their farm production and income, and new tools and concepts to manage these risks better in the future. Results from the Mallee Sustainable Farming Project cropping systems study will also be of interest to Upper Eyre Peninsula farmers.

Commodity price fluctuations present another risk (and opportunity) with which farmers have to contend. The range of marketing options and products for grain growers to manage price risk is increasingly varied and complex. But, as many farmers experienced in 2002, these risk management tools are not without their own risks, and need to be used wisely. The pro's and con's of some of the more common grain marketing options are discussed in this section.



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UNITED GROWER HOLDINGS

Maybe I should have listened to that El Niño bloke!

Jim Egan,

SARDI, Port Lincoln

Key Messages

- **District yield predictions for the 2002 season, based on early season rainfall and ENSO forecast indices, identified the high risk of poor yields across the State.**
- **Such yield forecasts are expressed as probabilities, rather than categorical predictions of what is expected to happen.**

Why do the trial?

Our climate risk decision support trials conducted with farmers around the grain growing districts of SA over the past seven years have tested the value of providing climate information to them during the growing season, to specifically assist their crop management decisions. An important component of this information has been the prediction of likely crop yields, based on early season rainfall (i.e. up to seeding) and forecast indicators of the El Niño - Southern Oscillation (ENSO) phenomenon, including the Southern Oscillation Index (SOI).

The extreme dry 2002 season provided an opportunity to assess just how well (if at all) these indicators were able to give advance warning of the imminent drought conditions and crop losses across much of the State. It is also interesting to compare the early season predictions for 2002 with those for the 2001 "bumper" season (see Eyre Peninsula Farming Systems 2001 Summary pp 148-150).

How was it done?

District wheat yield probability charts were produced with the test version of the Climate Calculator software being developed by David and Shaun Tennant, for WA Department of Agriculture. Charts were produced for 21 districts (Local Government Areas) across low, medium and high rainfall regions of SA, using annual wheat yields for 1901 to 1999 generated with the STIN (stress index) model, and supplied by Dr Andries Potgieter of Queensland Department of Primary Industries.

These charts showed how the probability of district yields being "Poor" (in the lowest third of all yields for the 99 year period), "Average" (middle third) or "Good" (top third of all yields) is influenced by factors including early season rainfall and the SOI. Charts were updated regularly during April through to July, with progressive rainfall totals and most recent forecasts such as SOI values, and included with the climate information emailed or faxed to trial participants each fortnight during this period. An example of these yield probability charts is shown in Figure 1.

What happened?

Table 1 summarises the yield probabilities for 5 of the low rainfall districts in the trial, calculated with information as at the end of May 2002: i.e. the local April-May rainfall total, the "Falling" SOI phase in April-May, and the Bureau of Meteorology's estimate of a high chance (70-80%) of El Niño developing later in 2002.

The near average or better start to the season at Minnipa, Kimba and Orroroo, as shown by April-May rainfall in the decile 5 range or higher, indicated no strong shift away from near average yield expectations. At Karoonda and Waikerie, where the season start was below average (deciles 2 and 4 respectively), likely yields were shifted towards the poor end of the scale. Stronger signals for likely yields were provided by the ENSO indicators at the end of May, however. Both the "Falling" SOI phase in April-May and the forecast of a strong likelihood of El Niño developing shifted yield expectations downwards in all districts, especially at Orroroo where the "Falling" SOI indicated a 75% chance of Poor yields and only an 8% chance of Good.

Total growing season (April-October) rainfall was below average right across the agricultural districts of the

Figure 1: Example district wheat yield probability chart, showing chances of Poor, Average and Good wheat yields at Kimba in El Niño years (left) compared with the "all years" (normal) expectations (right chart).

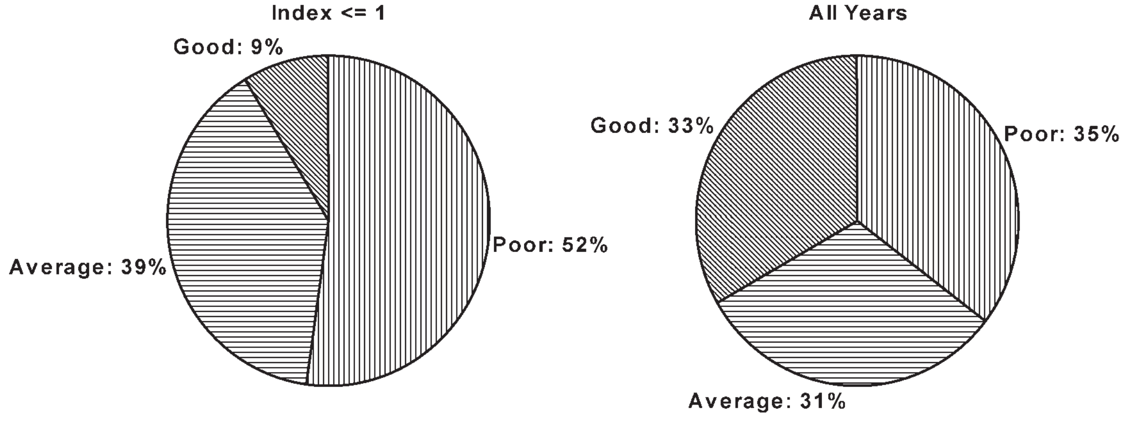

Table 1: District wheat yield indications at end of May 2002 for 5 low rainfall locations in SA, based on early season rainfall and seasonal forecast indices, and actual district yield outcomes.

LOCATION	APRIL-MAY RAIN Total mm & (Decile)	CHANCE OF YIELDS BEING "POOR" (lowest third) OR "GOOD" (top third), BASED ON:						Actual District Yield Outcome
		April-May rain		April-May SOI phase "Falling"		El Niño year likely		
		Poor	Good	Poor	Good	Poor	Good	
Minnipa	53 mm (6)	21%	28%	50%	17%	57%	17%	**Average**
Kimba	72 mm (7)	26%	39%	50%	17%	52%	9%	**Average**
Orroroo	47 mm (5)	38%	34%	75%	8%	61%	13%	**Poor**
Waikerie	29 mm (4)	45%	27%	67%	17%	57%	13%	**Poor**
Karoonda	32 mm (2)	59%	21%	50%	25%	52%	22%	**Poor**
NORMAL EXPECTATION		***33%***	***33%***	***33%***	***33%***	***33%***	***33%***	

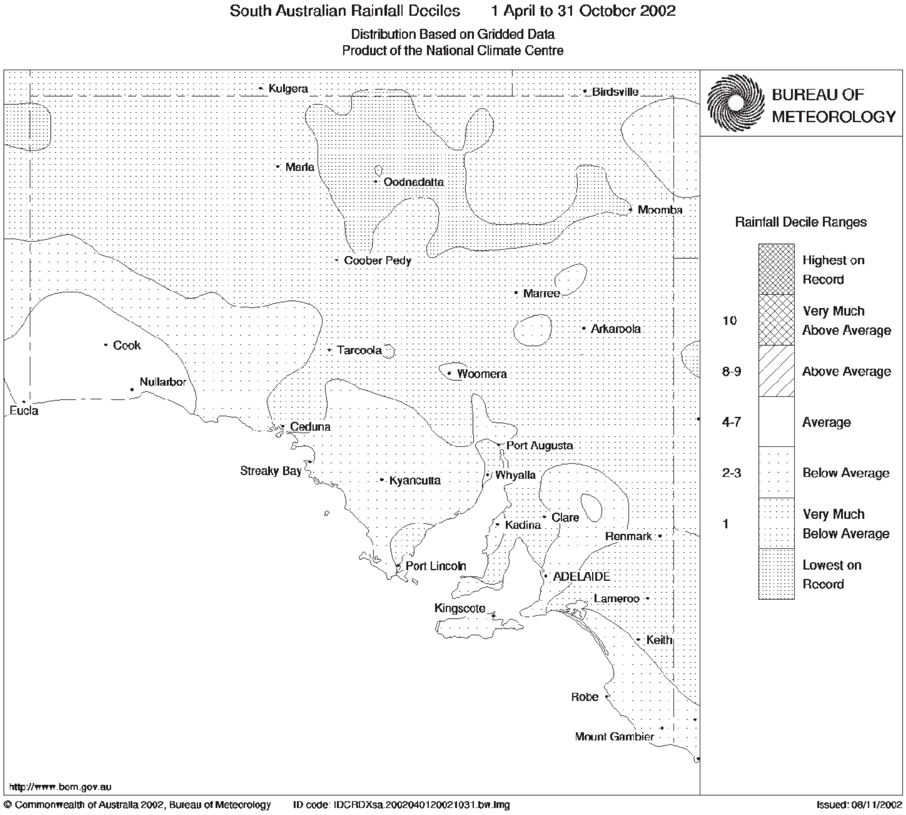

Figure 2: SA growing season (April-October) rainfall deciles for 2002.

State, ranging from decile 1 (i.e. in the driest 10% of years) through much of the Murray Mallee, Lower, Mid and Upper North and some parts of Eyre Peninsula, up to decile 3 in the Lower South East, Adelaide Hills, Kangaroo Island and most of the Eyre Peninsula (see Figure 2). As a result, district yields generally ended up in the Poor range (lowest third) in the Mallee and Upper North, but in the Average range (middle third, or between about decile 4 and 7) around Minnipa and Kimba. The better start to the season and up to the end of July in these Upper Eyre Peninsula districts would most certainly have helped them achieve yields closer to average than in other regions of the State where the drying El Niño effects were experienced earlier in the season.

What does this mean?

The results indicate some success in early recognition of a major drought season with extremely depressed crop yields in much of the State. These conditions were most severe where both early season rainfall and the forecast indicators pointed to low yields, and less severe where better early seasonal conditions tended to offset the dry forecast spring. However, none of the early indicators, either early seasonal conditions or forecast indices, provided any hint of the extent and severity of the pending dry. One of the challenges for future development is to combine the effects of seasonal conditions to date with the forecast indices to produce a single yield probability estimate.

I should also emphasise that, at our current level of knowledge of the systems that drive our climate, it is not possible to predict development of ENSO conditions with absolute certainty. Nor is it currently possible to predict with certainty where and to what extent a developing El Niño event will impact on our weather conditions. For the immediate future at least, such seasonal forecasts will be as probabilities rather than categorical predictions of what is expected to happen.

Acknowledgements

My thanks to SARDI colleagues Melissa Truscott and Anna Traeger who worked with me on the 2002 decision support trial, and to the many farmers who willingly cooperated in this study. Thanks also to Dr David Tennant and the WA Department of Agriculture for allowing us to use the Climate Calculator software, and to Dr Andries Potgieter of the Queensland Department of Primary Industries for providing the STIN wheat yield data used in this trial. Funding for this research has been provided by GRDC.

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Forward Pricing Tools for Wheat - a Review

Brenton & Chris Lynch

Lynch Farm Monitoring, Wudinna

Why forward price wheat?

The reason why farmers look to forward price wheat is to take the downside risk out of wheat prices. To forward price a parcel of wheat is to accept that you are happy to receive that price for your wheat at the end of the year. It is unreasonable to expect to forward sell your wheat at the top of the market for the year. If you achieve a good average price over all forward sales and eliminate downside price risk, you have done well.

If we knew we were never going to get prices like $107/t for wheat (1990/91) ESR Port Lincoln, or $146/t ESR Port Lincoln (1993/94) or $152/t ESR Port Lincoln (1999/00), we would not have to worry about pricing wheat forward. These pool returns would all be well below most EP farmers' cost of production for wheat.

The last time forward pricing fell out of favour with farmers was after similar pool returns to what we have now, in 1995/96 ($236/t ESR Port Lincoln). For the next five years, pool returns were:

1995/96 $236/t

1996/97 $188/t ↓

1997/98 $174/t ↓

1998/99 $163/t ↓

1999/00 $152/t ↓

In each of these years better prices than the pool end result were available earlier in that year.

Just when people threw away the forward pricing tools was exactly when they paid off - for the next 5 years. We must surely be in the situation now where there is more potential for downside than upside on 2003/04 wheat prices.

How do forward pricing tools compare?

1. **Fixed Price Contracts (AWB/AusBulk)**

   FOR
- Simple and easy to use.
- Small parcels for part of an overall marketing strategy.
- Fixes the $A, futures and basis all in one hit.
- Provides a guaranteed minimum price on part of the crop.
- Are on offer for three seasons out, with AusBulk.

  AGAINST
- Locks out any upside after it is taken.
- Have to physically deliver the grain.
- Only protects a minority of crop price (to the limit which you are prepared to contract).
- All taxable income in the year of sale.

2. **AusBulk Basis Contracts**

   FOR
- Can split the decision on when to fix the futures component, the $A and the basis.
- Quite easy to administer, with AusBulk.
- Reasonably small lots of 136t.
- Can deliver a variety of grades.
- Quick payment (70% harvest, 30% March).

  AGAINST
- A management risk in knowing how and when to fix each of the three components of price.
- Once all three components are set, it locks out any further upside.
- All taxable income in the year of sale.
- Have to physically deliver the grain.

3. **AWB Basis Pool**

   FOR
- Can split the decision on when to fix the futures component, the $A (you get the same basis as the AWB national pool).
- AWB "Risk Assist" section will help with decision on managing the contract (at cost approx. $6/t).

  AGAINST
- A large parcel for many farmers (952t).
- A management risk in knowing how and when to fix price components (despite advice available from Risk Assist AWB, the final decision is yours).
- Have to physically deliver the grain to AWB.

4. **NAB wheat swaps**

   FOR
- Take the futures and the $A at the same time, locking in gains available at the time (especially if the $A is down, and the futures are up).
- Do not have to manage basis. If you deliver wheat to the AWB pool, you get that basis.
- Do not have to physically deliver wheat to anyone - a major advantage. Wheat can be sold in whatever manner you wish, as the instrument is cash settled. If price goes above your contracted price, you pay NAB (and sell your grain at the higher price). If price goes below your contracted price, NAB pays you (and you sell your grain at the lower price). Whatever happens you get your nominated price at the time you set the futures/currency with NAB.
- Are on offer for 2002, 2003 and 2004 years at present.
- Can trade out of your position at any time by cash settlement (you do not have to deliver the grain).
- No margin calls or brokerage.
- Reasonably small parcels (100t each).

  AGAINST
- Can lock out possible upside on price after being taken.
- You have to lock in the $A and futures at the same time (I think this can be an advantage too, because there is a chance of getting it wrong, if you do not get the timing on both right).

Farming Risks on Upper Eyre Peninsula

Nam Nguyen, Ian Cooper and David Coventry

Department of Agronomy and Farming Systems, The University of Adelaide

Key Messages

- **Climate and economic exposure are the major sources of farming risk on Upper Eyre Peninsula (UEP).**
- **The main management strategies for these risks are: diversifying varieties; reducing tillage (no or minimum tillage); minimising area of risky crops (pea, canola, vetch) and maximising area of least-risk crop (wheat); having high equity; having farm management deposits and off-farm investment.**

Why do the study?

Eyre Peninsula has a long history of being a significant contributor to the State's economy due to agricultural production, but it is also recognised as a region of high agricultural risk. Many publications have been written on agricultural risk and risk management on Eyre Peninsula. However, most of these publications were focused on one type of risk only (e.g. climatic, land degradation, tillage technique or financial risk).

Therefore, this study was carried out to highlight ways farmers manage the major types of risk on Eyre Peninsula - especially on UEP, which has low and variable rainfall, difficult soils and restricted cropping options.

This study was undertaken as part of the work for a Master of Agricultural Business degree in the Department of Agronomy and Farming Systems, University of Adelaide.

How was it done?

The study involved a review of the major sources of farming risk (production, financial, marketing, policy and personal risk). The key feature of the review was the use of data from the Cropping 2000 survey previously undertaken by Jay Cummins and supported through Primary Industries and Resources South Australia and a Grains Research and Development Corporation Research Fellowship. The data were used to gain an overview of UEP farmers' characteristics and their relation to risk management. The study then analysed risk management strategies which are applicable to farm businesses on UEP. To add a "reality-check" to the literature sourced, a selective interview approach was undertaken to provide more specificity on risk management by UEP farmers.

What happened?

One hundred and seventy five responses from farmers on UEP were selected from the Cropping 2000 survey responses and analysed. Although too general to provide sufficient insight into individual risk management, these responses did reveal the following important points regarding risk management on UEP:

- The young farmer group (those less than 40 years old) had a higher level of education than the medium farmer group (those in the ages between 40 and 60) and the older farmer group (those more than 60 years old).
- These young and medium groups were more innovative and carried out practices related to risk management, such as gross margin planning and grain marketing planning, more often.
- In terms of trying new technology, the older group was less risk-taking than the young and medium groups. For example, the older group strongly agreed that they would not try a new chemical until it was well proven in the district.
- The older group was more likely to consider themselves as fairly conservative and traditional farmers.
- The young and medium age groups were more likely to plan ahead in farming, independent of weather conditions.
- All groups felt the marketing of their grain was best left to the experts, such as the AWB. They also agreed to some extent that the key to good farming is minimising costs.
- The young group slightly had higher skills in computing and grain marketing. On average, the three groups had the same farm business management skills.
- The low-level education group (those who only completed primary school or part of secondary school) had been involved in farming and managing farm business for a longer time than the medium-level (those who completed secondary school or TAFE, agricultural college) and high-level groups (those having tertiary or postgraduate level qualifications). The former group was also older than the latter two groups.
- In term of risk management practices, the most highly educated group followed a grain marketing plan more often. However, there was no difference in the frequency of practising gross margin planning between the three groups.
- The low and medium level education groups regarded themselves as more conservative and traditional.
- The most highly educated group was more risk-taking in trying new technology, such as new chemicals.

- Generally, the most highly educated group had better skills at computing, grain marketing and farm business management.

To provide more power and specificity to these points, selective interviews were conducted with five Eyre Peninsula farmers. The objectives of the selective interview approach were to:

- record how individual farmers define risk;
- gain feedback from farmers on the sources of risk as given in the literature and risk management strategies;
- determine whether the characteristics as given above reflect UEP farmers;
- examine the practical strategies that farmers have been implementing to manage farming risks.

An introductory letter and issues for discussion were sent to each farmer in advance. Attached with this letter, as background reading, was a draft copy of the study. Some important parts of this draft were highlighted to attract farmers' attention. The interviews were undertaken at the farmers' houses, approximately one week after they received the letter and the draft copy. The main responses/comments from these interviews are summarised below:

- Climate variability (production risk) is often the first source of risk that respondents mention;
- Financial risk was seen by respondents as the "automatic follow" of production risk;
- Marketing and policy risk are very unpredictable and the respondents consider they often have no control;
- Personal risk, which is normally ignored by farmers as one respondent commented, is seen as becoming a major concern on UEP in the near future, especially the reduction in people continuing in rural areas and the need for farm succession planning;
- Improved financial, computing and business management skills have helped some UEP farmers better cope with problems. However, more training and the willingness of farmers to undertake this are required;
- Practically, farmers have implemented many strategies to manage farming risks. In managing production risks, diversifying varieties and minimising tillage (no or minimum tillage) are commonly used. Moreover, farmers often minimise areas of risky crops (pea, canola, vetch) and maximise area of least-risky crop (wheat) to avoid risk;
- Having high equity and off-farm investment are the most frequently used strategies to manage financial risks. Other common strategies are using gross margins and having farm management deposits;
- "Leaving to experts" is the strategy that farmers normally use to manage marketing risk. It is agreed to a large extent that grain marketing is better left to experts such as the AWB. Farmers shared a common idea that it is better for them to focus on improving yields, crops, etc (issues they are good at) rather than staying in the office and studying forward prices, contracts, etc. These jobs should be left to consultative and advisory companies. The farmers also prefer storing grain on-farm to sell later if they anticipate price rises.

What does this mean?

Farming risk is an accepted reality in the Upper Eyre Peninsula and, as they have a greater exposure to such risk, farmers here are well advanced/adapted in their understanding of risk management. However, favourable seasons and/or improved technologies can tend to mask ongoing requirements for prudent risk management considerations, such as those highlighted above.

Acknowledgements

Jay Cummins for his excellent advice and help in providing the survey data. All the farmers for being involved so willingly in the selective interviews.

Reference

Nguyen, C.N. (2002). Farming Risk in the Upper Eyre Peninsula. Master of Agricultural Business Thesis, Roseworthy Campus, The University of Adelaide.

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Benefits of Intensifying Cropping Practices in the Murray Mallee

Victor Sadras and David Roget

CSIRO Land and Water, Adelaide

Location
Waikerie

Rainfall
Av. Annual total 267mm
Av. Growing season 176mm

Soil Type
Sandy soil in typical mallee dune-swale
Surface pH 8.0

Key Messages

- **A 4-year field trial at Waikerie showed an intensive, flexible cropping approach involving the opportunistic selection of crops, and matching nitrogen fertiliser rates to soil and seasonal conditions, generated a cumulative gross margin of about $880/ha. This compared with $440 for a low input wheat/pasture rotation representing district practice.**
- **Modelling the long-term outcomes of this intensive approach revealed a win-win situation: modelled economic benefits were in tune with field findings, and expected environmental outcomes were positive or neutral.**
- **Modelling experiments highlighted the need to match nitrogen input to soil and seasonal conditions to raise water use efficiency. In comparison with current practices, intensive cropping reduced simulated deep drainage and did not increase simulated nitrogen leaching despite substantial increase in nitrogen input to the system.**

Why do the study?

Low and highly variable rainfall are major sources of risk for farms in the Mallee, where risk management is largely based on a low input approach to minimise costs and losses in poor seasons. This approach has substantial opportunity costs, missing the benefits of wetter seasons, and low yield per unit rainfall - two thirds of crops in the Mallee are well below the attainable yield/rainfall ratio, and low nitrogen availability is one of the causes. Alternative approaches are required to manage risk and capture the benefits of good seasons.

How was it done?

A trial with four replicates was established on a coarse textured calcarosol at Waikerie. We compared a range of district practice treatments (e.g. low input wheat/pasture) against an intensive, flexible cropping approach involving an opportunistic combination of crops, and a close matching of nitrogen input to soil and seasonal conditions. Modelling experiments tested the long-term economic (yield, gross margin) and environmental (N leaching, deep drainage) outcomes of the intensive farming approach. A locally tested model (CropSyst) with proven ability to capture crop responses to management, soil and climate factors was used. In both field and modelling experiments, gross margin was calculated as the difference between gross income (calculated as a function of grain yield, grain price and freight) and variable production costs, i.e. tillage and cultivation, herbicides, fertilizers, insurance. Commodity price expectations and actual costs were obtained from selected farmers in the region (M. Krause, unpublished data).

What happened?

Table 1 shows the economic output of the intensive cropping strategy, as compared to district practice (wheat/pasture) and a fixed wheat/pulse rotation typical of higher rainfall regions. At the end of the field trial, cumulative net profit of the intensive approach doubled the profit corresponding to current district practice and reduced its variation; the fixed wheat/legume approach was intermediate. Main features of the intensive approach included the possibility of growing successive wheat crops provided there are no biological constraints (1998-1999), the opportunistic use of canola as a break crop in the case of an early onset of seasonal rainfall (2000), and the high yield of wheat following canola. The fixed wheat/pulse approach illustrated the high risk of untimely sown grain legumes (1999), and the benefits of growing wheat after a legume crop. The benefits of growing cereals after canola or legumes in the Australian wheat-belt are well documented.

Together with the encouraging findings of the field study, there are new emerging questions. Would the benefits of the intensive approach persist in the long term? What is the probability of intensive cropping leading to economic loss in extremely dry seasons? A combination of field and modelling experiments provide answers to these questions. Gross margins calculated using simulated grain yield during 44 seasons at Waikerie averaged $152/ha for flexible cropping, compared with low input, fixed rotations yielding between $55/ha (wheat/canola) and $113/ha (wheat/field pea). Figure 1 illustrates the long-term simulated yield response of crops managed with a fixed input of N (5 kg N/ha) as opposed to a flexible N input aiming at matching fertiliser to soil and seasonal conditions. Low-input crops were largely unresponsive to higher soil moisture, whereas a variable rate of fertiliser accounted for a steady yield increase with increasing soil water content at sowing.

What does this mean?

Overall, our study indicated more intensive, flexible cropping approaches are feasible in terms of input requirements as related to techniques (e.g. soil sampling and analyses) and timeliness necessary for decision-making, and could enhance and stabilize economic benefits with neutral or positive effects on deep drainage and nitrogen leaching. Despite substantial increase in fertilizer rate (up to 100 kg N/ha/yr compared to 5 kg N/ha/yr used in current practice), simulations indicated no substantial increase in nitrogen leaching with the more intensive approach. Simulated drainage beyond the root zone decreased with cropping intensification. The responses to opportunity cropping outlined in this report can only be achieved where there are no other key constraints to yield such as subsoil issues, non-wetting sands, diseases or P tie-up.

The approach to intensification in this research provides a platform to improve profit and to reduce its seasonal variation with overall neutral or positive effects on environmentally relevant processes. These benefits could be worth exploring in other semiarid environments where low-input strategies are the dominant approach to risk management.

Editor's Note: For an interesting update on how the 2002 drought conditions affect these findings, readers should refer to the paper by Roget, Gupta and Davoren in section 12 of this manual titled, Mallee Sustainable Farming Project.

Table 1: Gross margins of three cropping strategies in a field trial at Waikerie. All values are in $/ha, except the coefficient of variation (%).

YEAR	TREATMENT		
	INTENSIVE	WHEAT / PASTURE	WHEAT / PULSE
1998	232 (wheat)	221 (wheat)	232 (wheat)
1999	110 (wheat)	40 (pasture)	-87 (vetch)
2000	234 (canola)	143 (wheat)	222 (wheat)
2001	306 (wheat)	40 (pasture)	162 (field pea)
TOTAL	882	444	529
Coeff. of variation	36	71	102

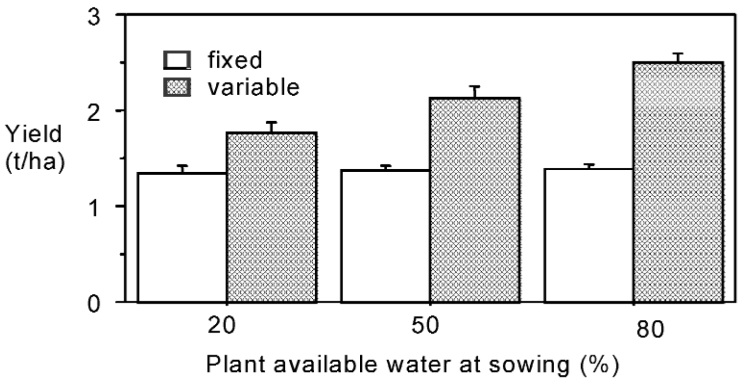

Figure 1: Simulated wheat yield at Waikerie in response to plant available water at sowing and N fertilizer strategy. Each value is average of 44 seasons encompassing a range of seasonal rainfall from 53 to 334 mm.

Best practice **Try this yourself now** **Almost ready** **Searching for answers** **Searching for problems**

Key to symbols

Frost Research

Melissa Truscott,
SARDI, Waite Research Precinct

Key Messages

- **There are agronomic practices that alter the soil heat bank to release latent heat to crop canopy height.**
- **Look out for the frost risk workshop in your area, to determine which frost risk management practices you could trial and monitor.**
- **Assess your frost risk.**
- **Spread your risks by choosing sowing date and variety alternatives.**

Why do frost risk research?

In high frost-prone areas, 25-80 % of crop area is lost to frost in any year. In areas such as the Tatiara district of SA, the area sown to crop is increasing as land grazed decreases. With improved machinery, growers can sow a greater amount of crop faster and more efficiently. Crops sown at the same time will flower at the same time. This exposes a larger amount of crop to frost risk damage resulting in economic loss.

In 2000 and 2001 most grain growers in SA recorded their highest yields ever. But on October 20, 2001, very cold air was carried in from the Antarctic to parts of the Murray Mallee, settling on large areas of crop, freezing the grain and causing the potential record harvest to be completely ruined. This was very devastating to many growers, especially those who experienced similar events 2 years in a row. To some extent the shock of frost is worse than a drought because grain growers have no time to prepare or get used to the idea of such losses.

Recent frosts have also resulted in large losses in WA in 1998 and 1999, and in other parts of SA. GRDC has recognised this by providing funding to SARDI and to WA for frost research.

The aims of SARDI's research are to:

- Utilise agronomic practices to alter the soil heat bank and increase the temperature at crop canopy height
- Further investigate the economic benefits of delaying sowing
- Develop frost decision rules for various environments.

How is it being done?

SARDI is collaborating with WA and Victoria in the frost research project to test agronomic practices which alter the soil heat bank, allowing latent heat to be released at night from the soil and rise up through the canopy of the crop. The idea is to have an open canopy so that the heat can rise and not trap cold air. Preliminary suggestions to achieve this, based on previous research by the WA Department of Agriculture, a survey of frost-hit farmers in the Murray Mallee, and consultants' observations, include:

- Wider row spacing
- Clay spreading
- Reduced seeding rates
- Rolling / press wheels after sowing
- Black mulch
- Spreading sowing dates and a range of varieties.

SARDI conducted its first year of trials in SA (at Mintaro in the Mid North) and Victoria in 2002. WA conducted trials also. The agronomic practices in the 2002 trials were:

WA

Paddock standard - Camm and Carnamah wheat

Wide rows - Camm and Carnamah

High nitrogen (55 kg/ha) - Camm and Carnamah

Potash treatment (MOP @ 100 kg/ha) - Camm and Carnamah

Clay

SA

Paddock standard - Buckley and Durum wheat

Wide rows - Buckley and Durum

Wide rows and low seeding rates - Buckley and Durum

Black and white mulch

Victoria

Paddock standard district practice- Frame wheat

Normal row width, high seed rate - Frame

Double row width, normal seed rate - Frame

Double row width, high seed rate - Frame

What happened?

In the Mintaro trial, Buckley yielded better than the durum wheat, which performed very poorly in the wider rows. Buckley seemed to be better at storing carbohydrates than the durum, and we believe that Buckley is more drought tolerant than durum. It is noted that varieties with less awns are less frost susceptible, since awns can trap cold air and channel it down to the seed. Buckley has less awns than the durum variety.

We recorded significant frost events, with minus 8°C being the lowest in September. During September we visually assessed performance of the black and white mulch, and it was very clear that the black mulch was thicker and healthier at this stage of the wheat development.

What does this mean?

Cold Air Flow

Other frost research has shown that cold air moves like water down a slope. Therefore if you can cut a crop to produce a tree-like channel down a hill, it can channel cold air away from a crop. Wide rows can also help to channel cold air away. It has also been suggested to sow a mixture of several wheat varieties. These will flower at different heights, making it harder for the cold air to settle on a flat surface.

Future Research

SARDI plans to conduct 3 frost trials in SA in 2003 and 2004, at Lameroo, Keith and Mintaro. There will also be an opportunity for farmers to become involved in this research. Temperature monitors will be available to measure temperature differences with various management practices on individual properties.

Assessing Frost Risk

The Flowering Calculator model developed by the WA Department of Agriculture predicts the date a crop is likely to flower for any given sowing date. It also illustrates the frost risky window. It is essential to calculate your frost risk so that you can better manage it and determine if it is worth your while to delay sowing to avoid frost. In some environments where a paddock is frosted almost every year it is certainly a viable option. However in low rainfall environments there is a yield penalty for delaying sowing. Rural Solutions SA and SARDI will be conducting frost workshops to assess frost risk.

Figure 1, from Flowering Calculator, shows the frequency that temperature has been less than 3°C for one or more days at Karoonda. This figure also shows that if Janz wheat is sown on April 25, it is likely to flower on September 19, when there is a 28% chance of frost.

Acknowledgements

Mick Faulkner of Agrilink for collaboration in the Mintaro trials and his wisdom and knowledge on frost. The WA Department of Agriculture for the use of Flowering Calculator, and previous frost research results from Craig White. Funding for frost research is provided by GRDC.

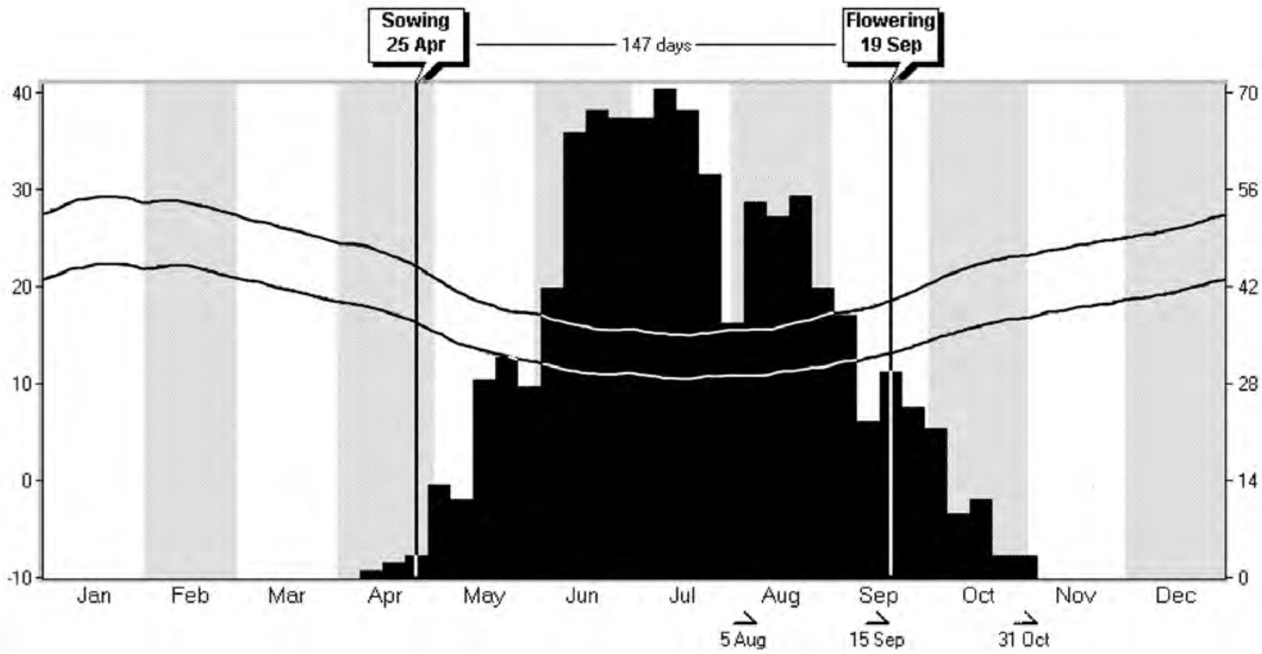

Figure 1: Frost frequency at Karoonda. The bars show the frequency that temperature has been below 3°C for 1 or more consecutive days (a frost).

Bush Tucker Project

Robyn Schmiechen[1] and Naomi Scholz[2]

[1]Aboriginal Lands Trust; [2]Western Eyre Peninsula Landcare

Location
Kalaya Tjina
Closest town: Ceduna

Rainfall
Av. Annual total 290mm
Av. Growing season 214mm

Key Messages Box

The Bush Tucker project aims to foster development of a sustainable Bush Food Industry, by:

- **providing best practice information about species, cultivars or hybrids in EP conditions;**
- **supporting Aboriginal communities and farmers wishing to diversify their farming activities;**
- **protecting wild resources for the future.**

Why do the trial?

The Bush Tucker project is aiming to evaluate the performance (survival, growth and yield) of a selection of native food plants grown under field trial conditions at a site near Ceduna, Eyre Peninsula.

The project is part of a national initiative by CSIRO Land and Water and Coles Supermarkets. They have joined forces with a number of community groups to help create a sustainable industry based on native food production, supported by information gathered in a series of trials throughout South Australia and Victoria.

Currently there is an over-reliance on wild harvest to supply the growing native food industry, and there is a need to cultivate native plants to satisfy future demand. The trials were designed to provide informed decision making on the choice of native food species or cultivars for climatic and soil type zones. The research will also assist with quality control and information on timelines of production, e.g. fruiting times.

The Ceduna trial is specifically designed to determine what will grow and perform in the Ceduna area. It is hoped that the trial will stimulate interest in native food production, encourage diversification of farming practices, help Aboriginal communities to establish new industries and be used as a 'best practice' demonstration site.

The Western Eyre Peninsula Landcare Management Group has provided financial support, through Natural Heritage Trust funding, for the Eyre Peninsula trial being conducted at Kalaya Tjina (The Emu Farm) near Ceduna. The land is owned by Tjutjunaku Worka Tjuta (TWT), who is also providing an Indigenous project supervisor. The Bush Tucker trial is also supported by the Aboriginal Lands Trust through providing time from the Aboriginal Landcare Officer.

How was it done?

Soil and water quality were tested, and the plant species to be trialed were chosen (see Table 1). Plant selections have been sourced from a range of suppliers. Most planting material was supplied by Australian Native Produce Industries, SA (ANPI) as well as 6 other nurseries in SA, Victoria and NSW.

Most species were planted on August 20 to 22, 2002, Bush Tomatoes and Sandalwood were planted in early December, and Sweet Appleberry and Sturt's Desert Pea are to be planted in 2003. Fifty of each tree species and 60 of each shrub species will be used, along with 100 Myoporum parvifolium (Creeping Boobialla) host plants for Quandong and Sandalwood. The climbers and ground cover species such as Bush Banana and Muntries are to be trellised in early 2003. Wind guards have been placed around the plants, which were fertilised using Nutricote® at the time of planting.

The trial design consists of 4 replicated blocks of 12 trees each. Shrubs have 1m spacing, trees have 4m spacings. The ground was deep ripped from 30-70cm along planting lines. Water is obtained from the Tod River Pipeline, using irrigation equipment designed and supplied by Netafim Irrigation. Slope and aspect of the site were taken into consideration in the irrigation design. Snail control was required in early November, and will be ongoing throughout the trial as necessary.

Plant height and vigour will be measured 3-4 times per year for the first two years, and experimental treatments, e.g. watering or fertiliser regimes, may be included at a later stage to generate practical information for growers.

What happened?

The Bush Tucker project has not been operational long enough to produce much data at this stage. Initial plant measurements for height and vigour were recorded at the time of planting, and one subsequent measurement was undertaken in November 2002. The survival rate is encouraging for most species, although Muntries is not doing as well as the other species (see Table 1). The Konkerberry has best survived the stress of being planted out.

Table 1: Plant selection and survival rates to November 22, 2002

Scientific name	Common name	Production	Survival rate (%)
Santalum acuminatum	Quandong	Fruit	75%
Acacia victoriae	Elegant Wattle	Seed (flour)	79%
Citrus hybrids	Bloodlime Sunrise Lime Outback Lime	Fruit	75%
Santalum spicatum	Sandalwood	Kernel, wood	N/a (planted after measurements)
Marsdenia australis	Bush Banana	Fruit	79%
Billardiera scandens	Sweet Appleberry	Fruit	N/a (to be planted in 2003)
Kunzea pomifera	Muntries	Fruit	57%
Clianthus formosus	Sturt's Desert Pea	Seed (further production)	N/a (to be planted in 2003)
Solanum centrale	Bush Tomato	Fruit	N/a (planted after measurements)
Carissa lanceolata	Konkerberry	Berries	95%

What does this mean?

While the Ceduna trial is still in the establishment phase, future results of the Bush Tucker project should indicate the best plants to grow on the Upper Eyre Peninsula. Results will be available from the contacts listed below. Further information is also available at the website: www.clw.csiro.au .

Acknowledgements

The support of the following groups and organisations is gratefully acknowledged: CSIRO Land and Water; Natural Heritage Trust; Aboriginal Lands Trust; Landcare on Eyre - Western Eyre Peninsula; Tjutjunaku Worka Tjuta Inc.; ANPI; PIRSA; RIRDC.

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Key to symbols

Section 11

Section editor: Samantha Doudle,

Eyre Peninsula Farming Systems Project Coordinator, Minnipa Agricultural Centre

"Sharing information between low rainfall agricultural areas"

Despite it seeming a simple thing, communication between similar farming systems projects hasn't been a high priority on anyone's agenda, compared to all of the work and communication to be done within each project. GRDC recognised the potential benefits of improving the communication between projects and recently provided the motivation and incentive to encourage this to finally happen officially.

We will all benefit from the new official link between the Central West Farming Systems Project (based at Condobolin), the Mallee Sustainable Farming Project (based in the Murray Mallee of SA, NSW and Victoria), the Upper North Low Rainfall Farming Systems (based in the upper north and lower Flinders) and the Eyre Peninsula Farming Systems project (Minnipa Agricultural Centre).

As part of this new alliance, we will include a chapter in our book (and they in theirs) every year, summarising any outcomes from their project's that are relevant to Eyre Peninsula. This year some of the articles in this section are of a more general introductory nature.

If your interest is sparked by something you read in the following pages why not ring them up (or us) and follow it up.

SARDI SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

UNITED GROWER HOLDINGS

Central West Farming Systems (CWFS)

Catherine Evans, Rob Sanderson, Bruce Watt and Neil Fettell

NSW Agriculture

Location
Condobolin, NSW
Co-operator: NSW Agriculture
Group: CWFS

Rainfall
Av. Ann. = 442 mm
Av. GSR = 251 mm
2002 Ann. = 306.5 mm
2002 GSR = 97.2 mm

Yield
Potential: different each year
Actual: see Table 1

Paddock History
Rotations for each system are:
Perennial pasture system - rotational cell grazing of each 10 ha block (not part of a 5-year rotation)
No tillage, no livestock - canola, wheat, pulse, wheat, green manure (pulse was field peas for 98-01 and lupins in 02: green manure crop was field peas in 98-00 and vetch 01-02).
Traditional - long fallow wheat, short fallow wheat undersown, 3 years of lucerne-based pasture (grazed)
Reduced tillage with livestock - long fallow wheat, skip (fallow for the year), long fallow wheat undersown, 2 years of lucerne-based pasture.

Soil
Red earth/ red-brown earth
Clay loam surface, slightly acidic (pHCa 4.6 - 5.2)
Medium clay c\subsoil, slightly alkaline (pHCa 8.5)

Diseases
None in 2002 - too dry

Plot Size
Approx. 2 ha

Other factors
Drought affected the whole region in 2002.

Key Messages

- **CWFS is a low rainfall farming systems group based at Condobolin in central-western NSW.**
- **Our aim is "Farmers Advancing Research".**
- **Our main focus is a systems comparison trial located at Condobolin, investigating the management, sustainability and profitability of 4 farming systems (grazed perennial pasture; no tillage, no livestock; traditional mixed cropping and livestock; and reduced tillage with livestock).**
- **We also have 10 regional trial sites across central-western NSW where local farmers conduct research that they're particularly interested in.**

Why do the trial?

CWFS was set up to increase research being conducted in central-western NSW, support the NSW Agriculture research station at Condobolin and increase farmer input into research and research directions. CWFS commenced trials in 1998 after much discussion and many months of planning. The main focus is a systems comparison trial located at Condobolin that began the first year of a 5-year rotational cycle in 1998 (more about that trial in the rest of the article). CWFS also has 10 satellite sites (called Regional Sites) located across central western NSW where research is farmer owned, farmer driven and important to the local farming community. Regional sites have started since 1999 and on some sites the trials have been continuous since then, whereas other sites change trials each year. Information on the regional site trials can be found in the CWFS Research Compendium and on the GRDC Web Site.

How was it done?

The Systems Comparison Trial is designed to look at the "extreme" systems for our area - 100% grazing of perennial pasture (perennial pasture) and 100% annual cropping (no tillage, no livestock) - as well as two middle of the range systems - traditional wheat and pasture system (traditional) and a modification of the traditional system (reduced tillage). There are 4 replicates of the 4 systems. The whole trial is 160 ha in size. Each of the 3 cropping systems has a 5-year rotational cycle with each phase present in each year (i.e. the 10 ha for each system in each replicate, is split into 5 x 2 ha blocks so that each phase of the rotation is grown in each year). We do this so that "bad" years and "good" years don't affect the data - it makes the statistics better.

We have tried to blend scientific needs with keeping the systems as close to a real farm as possible. We have a farmer committee and a chairperson who supervise each system. They have set guidelines for the systems and each system is managed according to these guidelines. We (the staff) check with them about things like choice of chemical, timing of cultivation, sowing, spraying and grazing.

On each system throughout the year we measure soil water (3 times a year), soil nitrate pre-sowing, crop emergence, head counts, yield, grain analysis, grazing days, livestock weights. In 1999 a full soil sampling of each plot to 90 cm was conducted so we could monitor soil changes over time (as a measure of sustainability). Livestock came into the system late in 2000 and so the livestock/pasture component of the data is poor but we will make sure that improves in the next 5 years.

What happened?

The crop results for the last 5 years are summarised in the following table (Table 1). Rainfall figures for the 6 years from 1997 - 2002 are presented in Table 2 and Gross Margins are presented in Table 3.

If you average the wheat yields for the 3 cropping systems over the 5 years, the results are Traditional = 1.94 t/ha; Reduced tillage = 1.98 t/ha and No tillage, no livestock = 1.96 t/ha. So although no full statistical analysis of the 5 year data has occurred, on face value it looks as though there is little difference between the 3 systems when comparing wheat yield alone. A full statistical analysis of the 5 year data is underway and this will give better results as to any differences between

Table 1: Grain yield (t/ha) and protein (%) of the Systems Comparison Trial from 1998 to 2002. (Key: LFW = long fallow wheat; SFWu/s = short fallow wheat undersown; LFWu/s = long fallow wheat undersown; SFWaC = short fallow wheat after canola: SFWaP = short fallow wheat after pulse).

	1998	1998	1999	1999	2000	2000	2001	2001	2002	2002
	Yield	Protein	Yield	Protein	Yield	Protein	Yield	Protein	Yield	Protein
Traditional										
LFW	3.37	11.7*	2.30	13.8	2.38	13.3	2.06	16.2	0.44	15.2
SFWu/s	2.67	11.8*	1.12	15.2	2.57	12.8	1.67	13.7	0.73	13.2
Reduced Till										
LFW	3.35	11.8*	1.98	14.6	2.17	13.5	1.69	14.8	0.14†	14.5
LFWu/s	2.71	11.8*	1.92	15.2	2.39	12.5	3.03	14.3	0.43	14.93
No Till										
SFWaC	3.14	11.8*	1.18	14.2	2.92	14.4	1.89	12.4	0.60	15.2
SFWaP	3.19	11.8*	1.38	15.1	2.60	12.5	1.92	13.8	0.73	13.5
Canola	1.04		0.36		1.34		1.21			
Peas	1.71		0.77		0		0.71			

** 1998 Protein not analysed for individual plots.*

† The H45 wheat was affected by the Glean® application prior to sowing - Glean was not used on other H45 crops.

Table 2: Monthly rainfall at Condobolin ARAS (1997 - 2002) - average annual rainfall = 442 mm

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	AAR
1997	21.6	6.0	4.1	0.9	44.6	16.3	15.7	27.4	122	24.0	27.8	6.6	317
1998	35.8	4.5	4.4	53.7	56.3	48.0	75.3	82.0	79.0	47.9	50.9	14.2	552
1999	37.2	16.3	73.3	34.5	7.0	26.9	53.2	41.9	16.8	122	16.9	128	574
2000	8.8	30.6	76.1	45.0	95.0	17.8	14.9	58.7	12.5	64.0	63.2	16.7	503
2001	2.2	39.9	38.2	16.3	27.4	51.0	28.6	19.6	42.0	25.4	46.6	2.8	340
2002	0.8	172	19.4	11	22.1	4.4	8	6.6	45.1	0	2.8	14.2	306.5

Table 3: Average and Cumulative Gross Margins ($/ha) for each cropping system 1998-2001 (Gross margins have not yet been calculated for 2002) NOTE: The gross margins for the systems have been calculated using only the cropping income and variable costs. This has penalised the Traditional and Reduced tillage systems which have a significant livestock component.

	average annual gross margin				4-year	cumulative
SYSTEM	1998	1999	2000	2001	average	98-01
Traditional	+104.52	+ 51.85	+ 64.26	+ 78.63	+ 74.82	+299.25
Reduced tillage	+113.13	+ 31.67	+ 36.75	+107.81	+ 72.34	+289.35
No tillage	+247.53	- 40.35	+108.92	+ 57.99	+ 93.52	+374.08

systems and within systems (eg long fallow vs. short fallow, undersown vs. wheat alone)

The gross margin results, although not complete and without the livestock component, do however show an increased fluctuation in gross margin with increased cropping (i.e. the no tillage, no livestock system has up and down years whereas the traditional system is more stable).

In central-western NSW there are no other trials like this. We will be continuing this trial hoping to answer farmers' questions - "Is direct drilling better? Should I be increasing cropping to have a more profitable farm? Does stock make my farm unsustainable by affecting my soil? Is 100% cropping sustainable?"

What does this mean?

After the first 5-year cycle, there appears to be very little difference between the 3 cropping systems in wheat yield or protein. If you put in a factor for the livestock component, there is also very little difference in gross margins between the 3 cropping systems. These results are not surprising as you need time for any changes caused by the system to take effect. The next 5 years are important and that will be when we may see changes between the 4 systems. We will also be soil sampling again to measure sustainability indices.

Acknowledgements

CWFS members have committed much time and energy into all the research. The Executive Committee of CWFS put in tremendous efforts and huge amounts of time. NSW Agriculture staff, in particular those at Condobolin Research Station and the district agronomists across central-western NSW, are invaluable to CWFS. The CWFS staff members who have done their time and have moved on - Jason Cameron, Mathew Ginns, David Flower, Linda Stockman and James Deeves.

Mallee Sustainable Farming Project

Viability of High Input Cropping in the Mallee - coping with drought

David Roget, Gupta Vadakattu and Bill Davoren,

CSIRO Land and Water, Waite Precinct, Adelaide, South Australia.

Key Messages

- **In a decile 1 drought there has been very little effect of treatment. The key benefit of improved systems has been the stability of soils through stubble retention, particularly in no-till systems.**
- **High input intensive systems gave double the GM loss compared to district practice (wheat/pasture) in 2002.**
- **Gross margins over 5 years show high input systems have returned double that of district practice.**
- **High input intensive systems are, on average, profitable 8 years in 10. The risk of higher losses in poor years is less than the risk of not realising benefits of better years.**
- **The value of reducing inputs in late breaking seasons to reduce risk is not clear.**

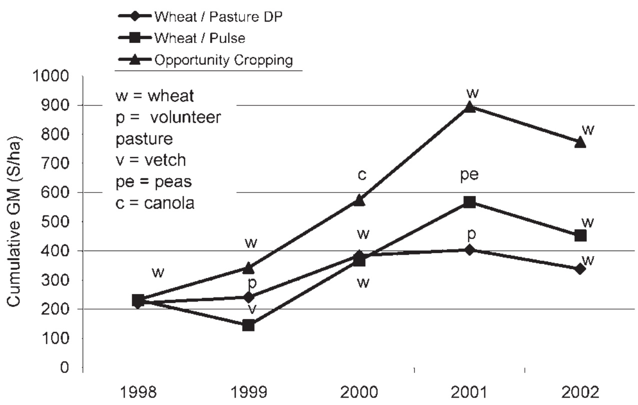

Figure 1:. Cummulative Gross Margins for 3 Farming Systems - MSFP Waikerie Core Trial, 1998-2002

Note: Grain prices based on average of previous 5 years.

Fertiliser use: district practice 10 P, 5 N; Intensive cropping 15P, 27 N, 1.5 Zn

2002 Season

The 2002 season at Waikerie SA was a decile 1 drought with annual rainfall of 125 mm (average 252mm) with 61 mm of effective rainfall in the growing season. Wheat yields were measured at 0.1 to 0.2 t/ha but these were probably underestimated due to limitations with the harvester. Canola was not harvested. There were no clear effects of previous treatments (tillage, rotation, fertiliser inputs) on final yield. However, treatments that had N remaining at the end of 2001 (peas, pasture, fallow) showed better early growth and had greater yield potential. Reduced erosion risk was a major benefit of the more intensive, no-till cropping systems where stubble was retained.

Long-term profitability of systems

Seasons like 2002 are to be expected on average once every ten years (decile1) so the farming system needs to be able to cope with them when they occur. Gross margins for all cropping treatments were negative in 2002 with losses in the high input systems ($115/ha) approximately double that of the low input conventional system ($66/ha). However the high input intensive opportunity cropping system has still produced over double the gross margin return compared to the conventional wheat pasture rotation over the last 5 years (Fig.1).

The drought has provided an opportunity to test our understanding of the farming system at Waikerie in terms of both yield and economic performance for a range of different seasonal conditions. As shown in Figure 2, the high input intensive cropping system out performs the district practice system from decile 3 to decile 10 i.e. on average in 8 years out of 10. The better performance of the high input intensive cropping system is due to:

1. Higher yields through improved utilisation of available rainfall due to better matching of nutrient requirements. Note: medic performance at Waikerie is poor (like much of the Mallee) and the low N input medics contributes to the reduced performance of the cereal /pasture systems.
2. Improved supply and efficient use of N from increased microbial populations and activities from increased residue input (stubble and roots).
3. More frequent cropping

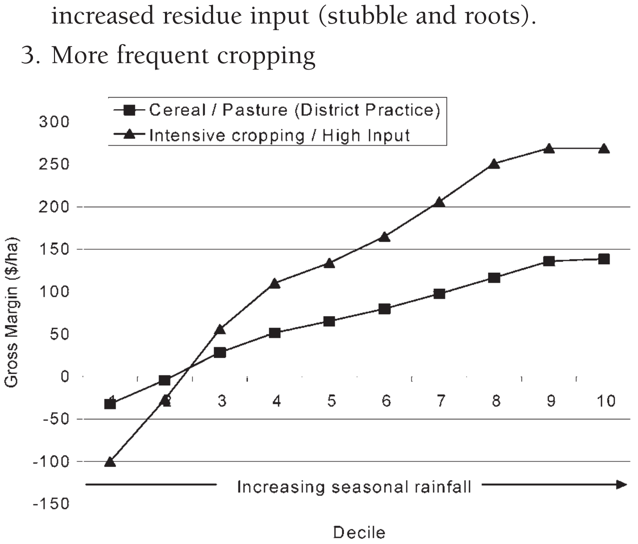

Figure 2: Impact of rainfall (deciles) on gross margins of farming systems Waikerie - 250mm Average Annual Rainfall

Managing the risk in higher input systems

High input, more intensive systems can obviously result in greater losses in years of very low rainfall. It is tempting to consider reducing inputs in years with unfavourable starts to the growing season in order to reduce risk of loss. However by reducing inputs there is the risk of not taking advantage of favourable seasons. Unfavourable starts to the season can actually result in reduced availability of N due to low microbial activity and may require higher use of fertiliser N to compensate. The best approach to managing risk is not clear cut however with a potential of achieving economic benefits from high input systems on average 7 to 8 years in 10 it is likely the benefits of applying higher inputs, irrespective of early seasonal conditions, is greater than the risk of losses. The difficulty in trying to pick seasonal responses has been demonstrated over the last 2 years where we have seen both record yields and a drought (Fig.3). In both years the first sowing opportunity occurred in the 2nd week of June with minimal water stored in the soil (12 mm 2001; 6 mm 2002).

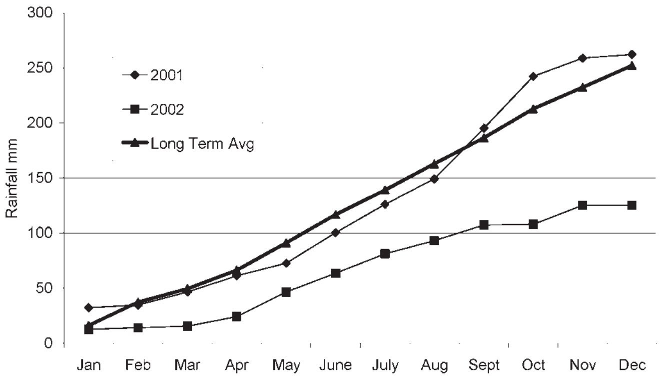

Figure 3: Waikerie Cummulative Rainfall

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Notes

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Key to symbols

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