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Crop Updates 2005 - Farming Systems

David Stephens
Department of Agriculture

Nicola Telcik
Department of Agriculture

Ross Kingwell
Department of Agriculture

Wayne Pluske
Nutrient Management Systems

Bill Bowden
Department of Agriculture

See next page for additional authors

Authors
David Stephens, Nicola Telcik, Ross Kingwell, Wayne Pluske, Bill Bowden, Mike Collins, Frances Hoyle, D. V. Murphy, N. Milton, M. Osman, L. K. Abbott, W. R. Cookson, S. Darmawanto, Bill Crabtree, Geoff Anderson, Darren Kidson, Ross Brennan, Nick Drew, Craig Scanlan, Lisa Sherriff, Bob French, Reg Lunt, Jeff Russell, Angie Roe, Ian Maling, Matthew Adams, George Yan, Mohammad Hamza, Glen Riethmuller, Wal Anderson, Angela Loi, Phil Nichols, Clinton Revell, David Ferris, Phil Ward, Andrea Hills, Sally-Anne Penny, David Hall, Michael Robertson, Don Gaydon, Tress Walmsley, Caroline Peek, Megan Abrahams, Paul Raper, Richard O'Donnell, Trevor Lacey, Meredith Fairbanks, David Tennant, Cameron Weeks, Richard Quinlan, Alexandra Edward, Chris Carter, Doug Hamilton, Peter Tozer, Renaye Horne, Tracey Gianatti, Paul Carmody, Ian Foster, Michele John, Ross George, Imma Farré, Ian Kininmonth, Dennis van Gool, Neil Coles, Bill Porter, Louise Barton, Richard Harper, Peter Ritson, Tony Beck, Chris Mitchell, Michael Hill, Fiona Barker-Reid, Will Gates, Ken Wilson, Rob Baigent, Ian Galbally, Mick Meyer, Ian Weeks, Traci Griffin, D. Rodriguez, M. Probust, M. Meyers, D. Chen, A. Bennett, W. Strong, R. Nussey, I Galbally, and M. Howden

FARMING SYSTEMS, 2005

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My sincere thanks to not only the authors of these papers but also the many more who contributed abstracts for the 2005 Agribusiness Crop Updates.

The response to the call for papers from the farming systems sector was enormous and showed the amount of work going on in a systems context. This in turn indicates that we are developing a real understanding of the importance of systems as opposed to individual industries.

Thanks to all authors, peer reviewers and colleagues for their assistance in enabling us to get this booklet together so quickly, under such a tight time line.

Many thanks also to Vicki McAllister and Natalie Lauritsen for their behind the scenes assistance. As always, it was invaluable.

Nadine Eva
FARMING SYSTEMS CONVENOR

2005 Seasonal Outlook

David Stephens and **Nicola Telcik**, Department of Agriculture, Western Australia

KEY MESSAGES

By the end of 2004 the eastern equatorial Pacific had gradually warmed to border-line El Niño conditions. More recently, Sea Surface Temperatures (SST) in the eastern Pacific began a cooling trend. This has coincided with a rise in the MeanSOI and strengthening of the Pacific trade winds. If these trends continue, more confidence can be placed in cropping programs in 2005. Most ocean-atmosphere models suggest that the Pacific should cool, with neutral conditions most likely by mid-year. For Western Australia, the DAWA analogue selection system indicates that neutral years, and average rainfall, are most likely across the wheatbelt between May and October. The system skill at predicting growing season rainfall at this time of the year is greatest for the central and southern wheatbelt.

Compared with 2002 and 2003, there is more uncertainty in the present weather pattern, so farmers are advised to keep monitoring updates through the season. Confidence in the selected analogue years will grow with the approaching growing season.

AIMS

This paper aims to review the broadscale weather pattern at the beginning of 2005 and the prospects of rainfall for the growing season for southern Australia, i.e. May-October.

METHOD

Possible seasonal scenarios for 2005 are developed using several approaches. These are ocean/atmosphere indicators in the Australian/Pacific region; a review of the main forecast model predictions; and, the outlook from a forecasting system being developed at DAWA.

Climate indices, developed by DAWA, include an El Niño Prediction Index (EPI) and a Mean Southern Oscillation Index (MeanSOI). The EPI is the largest three-month mean pressure anomaly averaged at Alice Springs and Mildura between July and September, or in the case of El Niño, is the standardised sea surface temperature (SST) anomaly in the eastern equatorial Pacific. The MeanSOI measures the pressure difference between Australasia and the Pacific Ocean. It is calculated by subtracting sea-level pressures at Darwin, Indonesia (INDO), Alice Springs and Mildura, from Tahiti, Honolulu, eastern equatorial Pacific (EPAC) and Rapa Island respectively.

These climate indices are combined with SST in the eastern Pacific (Nino-3 region), to form the basis of a 'big picture' monitoring of the ocean/atmosphere pattern. An experimental computer program called GESS (Global ENSO[1] Sequence System) applies weights to the importance of these indices through the year and uses pattern matching to select the most similar combination of indices from past years, i.e. analogue years. GESS is the first step forward to provide better long-lead rainfall outlooks. Future developments will add local and regional influences to this experimental system to create a new rainfall outlook system. Analogues and indices are updated monthly on DAWA's climate website www.agric.wa.gov.au/climate.

To assess the accuracy of the GESS forecasts, various skill measures have been calculated for past projections. Skill assesses how well the forecast performed compared with randomly guessing the rainfall category (below average, average, above average). For each month between 1969-2003 the median rainfall category of the five analogue years are compared to what actually happened. The simplest measure, which we illustrate below, is the success rate at predicting above median (middle ranking) rainfall.

[1] El Niño Southern Oscillation.

RESULTS

In 2004, the MeanSOI was volatile for the first half of the year, but its gradual progression to negative values coincided with strengthened high pressures over the Western Australian region. Due to this pattern, dry frosty conditions were a feature of the season's finish for much of southern Australia.

By the end of 2004 the eastern equatorial Pacific had gradually warmed to border-line El Niño conditions. However, in December and January (2005), pressures returned to more normal values in the Australian region, and the MeanSOI began to gradually rise. Pacific trade winds strengthened and Nino-3 SST in the eastern Pacific cooled from +0.7ºC to +0.3ºC by mid-January.

Of the 12 commonly used ENSO forecasting models, most are indicating a cooling in the eastern equatorial Pacific between April and August. However, this is some uncertainty about forecasts for later in the year. Of the three main scenarios (El Niño, neutral or La Niña), four models are suggesting 'El Niño-like' conditions will develop by May, while the rest (8) indicate that neutral conditions will persist. Of the nine models that predict through to September the majority (9:3) favour neutral conditions. March to June is known as the predictability barrier and predictive skill of the models across these months is at its lowest.

DAWA climate indices also indicate a cooling in the eastern Pacific, with neutral conditions most likely through 2005. In late 2004, the El Niño Prediction Index (EPI) was +0.34, which suggests a higher chance of cooling in the equatorial eastern Pacific over the next 12 months. Other years, with weakly positive EPI values were mostly neutral to weak La Niña events, with only 1951 and 1994 becoming an El Niño. GESS, currently selects the following neutral analogue years: 1947, 1978, 1980, 1981 and 2003 (based on preliminary data for January 2005, see Figure 1).

In Figure 1, the four analogue years (1947, 1978, 1981 and 2003) that had a rapid rise in the MeanSOI in March-May (year 0) had better growing season conditions. In contrast, the very dry 1980 analogue had a fall in the MeanSOI in autumn, with lingering negative values through the growing season. Figure 2 shows the Nino-3 SST patterns for the five analogue years. The years that had a rise in MeanSOI, generally had a cooling in Nino-3; while 1980 had lingering warm SST in Nino-3 in June (year 0).

In the Australian cropping zone, the pattern of growing season rainfall for the analogue years has:

1. 1947 – average rainfall Australia-wide.
3. 1978 – average to below-average, with wet July after a dry start (WA); average to above average in eastern Australia.
3. 1980 – drought in WA; average to below-average in eastern Australia.
4. 1981 – average to above-average in northern WA, average to below-average in southern WA; average to above-average in eastern Australia.
5. 2003 – mainly average, with above-average in southeast WA; average in eastern Australia, except in the northeast where it was below-average.

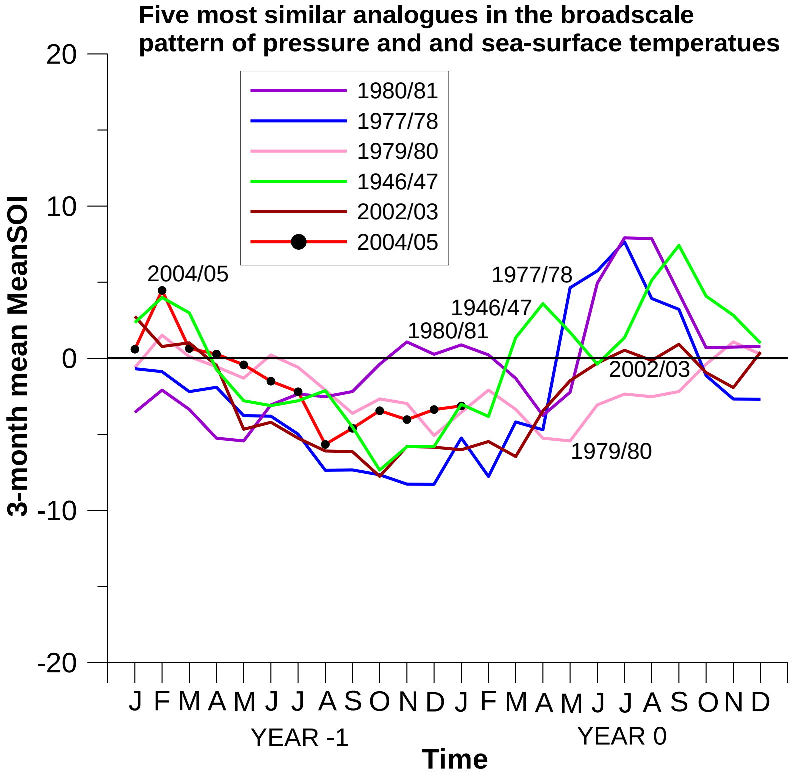

Figure 1. **The three-month mean of the MeanSOI for the five most similar analogue years selected in January 2005.**

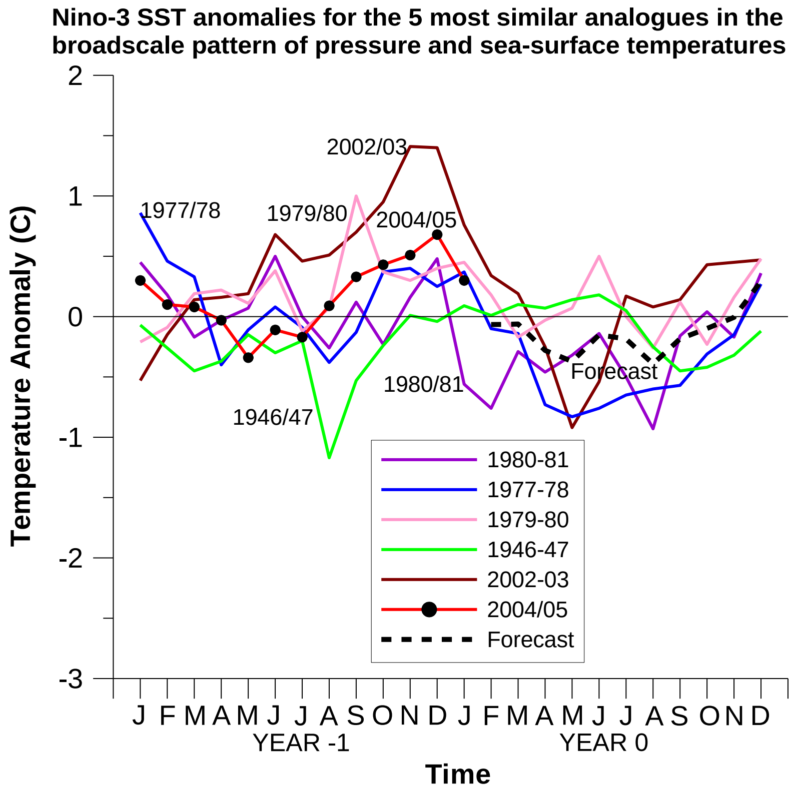

Figure 2. **Nino-3 SST anomalies for the five most similar analogue years selected in January 2005. The forecast of future SST changes is based on a simple mean of the five analogues and is shown with a dashed dark line.**

Thus, average rainfall is most probable for the majority of the cropping areas. To assess the confidence that we can put in the experimental GESS rainfall outlooks at this time of the year, we look at how well the system has performed in the past 34 years in February (Figure 3). This shows higher confidence can be placed in the median analogue rainfall in high and medium rainfall zones of the southwest. For these regions, the three months lead-time of the February analogues is a useful feature as it allows time to prepare for the 'type of season' that is expected. Outlooks made closer to the growing season generally have improved skill levels by the end of autumn.

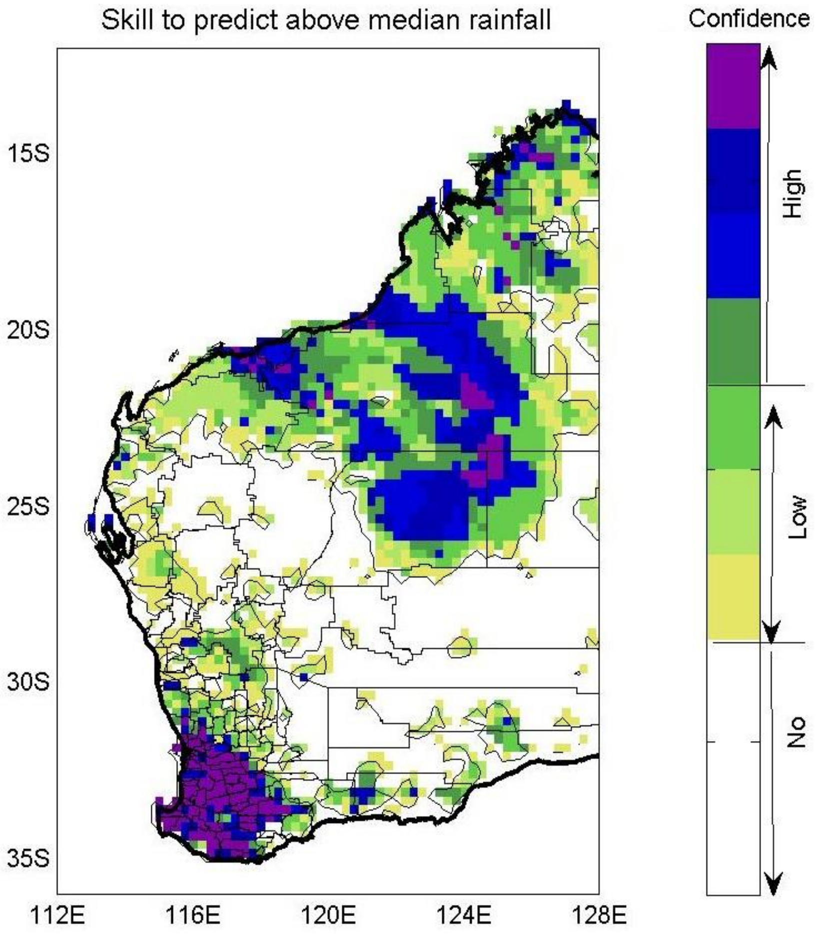

Figure 3. Success rate of early February analogues at predicting above median rainfall for the following May-October period. White - no confidence (success rate < 50%), yellow and light green - low confidence (success rate 50% to 69%). Dark green, blue and purple - high confidence (success rate > 70% of the time).

Research undertaken at DAWA, in collaboration with the CSIRO Marine Research, has found that an enhanced SST gradient (cool in south Indian Ocean, warm near Indonesia) is positively related to rainfall in the north-eastern wheatbelt (Merredin) where the GESS system shows less skill (Figure 3). In late January 2005, the SST was cooler than normal west of WA and warmer than normal off Sumatra. If this pattern persists, enhanced cloud-band activity and moisture inflow from the northwest could occur.

CONCLUSION

Recent trends in broad-scale indicators suggest that border-line El Niño conditions are beginning to decay and that more normal weather patterns should be established in 2005. If the cooling trend in the Pacific persists, and the MeanSOI continues to rise, then average rainfall is more likely. However, if the central and eastern Pacific remains warm and the MeanSOI negative, then drier conditions could continue. Farmers should respond to stored soil moisture and the timing of opening rains, but also pay close attention to updates of seasonal forecasts. Similar to 2004, there is a high chance of

analogue years changing as the season progresses, compared with 2002 and 2003. Overall, we would recommend a more confident approach to decision-making in 2005, although a more conservative approach would be appropriate should the equatorial Pacific fail to cool.

KEY WORDS

forecasting, rainfall, weather, climate, outlook

ACKNOWLEDGMENTS

Funding for research has been kindly provided by the GRDC Western Panel. Summary of climate models from the Bureau of Meteorology website and the International Research Institute (IRI) for Climate Prediction: http://www.bom.gov.au/climate/ahead/ENSO-summary.shtml and http://iri.columbia.edu/climate/ENSO/currentinfo/SST_table.html).

Project No.: Climate Risks and Opportunities Project (CROP)

Paper reviewed by: Ian Foster

The effect of higher nitrogen fertiliser prices on rotation and fertiliser strategies in cropping systems

Ross Kingwell, Department of Agriculture and University of Western Australia

KEY MESSAGES

Aside from the main influence of seasonal conditions and tactical opportunities, higher prices for nitrogen fertilisers should cause more grain farmers to economise on fertiliser use. Switches in wheat variety, crop type and even proportion of farm in crop are likely to form part of a rational response to higher prices of nitrogen fertilisers. Much tighter margins for many crops suggest a greater need for cost control and care in planning and implementation of cropping and livestock activity.

AIMS

To provide information to assist nitrogen fertiliser management.

METHOD

Apply economic and biological concepts and models to derive principles for managing nitrogen fertilisers.

RESULTS

Nitrogen fertiliser prices

Since mid-2004 prices of nitrogen fertilisers have increased sharply. Last year the prices of urea and DAP were around A$360 and A$440 per tonne ex-store (GST exclusive) respectively. But this year their prices are around A$420 and A$500 per tonne respectively. There are a range of reasons for the price increases and prices are likely to remain high in 2005 and possibly 2006. Higher prices are due to:

- Increases in natural gas prices, with natural gas accounting for 80% of the cost of ammonia. About 85% of the world's ammonia production is used for fertiliser production. A tonne of urea requires 0.58 tonnes of ammonia and a tonne of DAP uses 0.23 tonnes of ammonia.
- Very high demand from Asian countries for urea.
- Very high shipping costs with freight costs more than doubling since the start of 2003.
- Fertiliser plant closures and unplanned shutdowns in some major exporting countries that have restricted the availability of nitrogenous fertilisers.

Crop prices

The season 2005 price forecasts for most grains are not favourable (see Table 1).

Table 1. Grain prices

Crop	Unit	Season 2003	Season 2004	5 year average[1]	Season 2005 (est.)
Wheat	$/tonne	228	200	235	180 to 190
Lupins	$/tonne	225	180	228	165 to 175
Canola	$/tonne	413	365	409	320 to 340
Malt Barley	$/tonne	210	190	236	160 to 180
Feed barley	$/tonne	180	158	194	145 to 155

[1] Average prices from 2000/01 to 2004/05 using pool estimates.

Already prices for the 2004 crops are much below prices for the 2003 harvest. Unusually, prices for all grain types are forecast to be lower in season 2005. Some price forecasts are very pessimistic, with recent export subsidisation driving current prices lower. So in season 2005 we see the cost-price squeeze return with a vengeance. What are the implications for nitrogen fertiliser management?

Rational responses

Use less nitrogen fertiliser

The economics of fertiliser application is fairly simple. In general, when grain prices fall and fertiliser prices increase then to maximise profit from crop production requires a reduction in fertiliser applications. Exactly how much the reduction needs to be depends on site, season and market-specific characteristics. Tools such as grain price and nitrogen calculators help identify the nature and size of the reduction.

'Play the season' with bag nitrogen

If you are solely strategic in your application of nitrogen and apply rates suited to an average season then you risk reducing profit if the season turns sour and there is an uneconomic response to the applied nitrogen. You also miss out on high yields and higher profits, if the season is highly favourable, yet you under-fertilise. Whenever the strategic application of nitrogen ends up not matching the season that unfolds then profits are foregone. To lessen these foregone profits often it is best to 'play the season' by adjusting, where possible, basal and subsequent applications of nitrogen. The tactical use of nitrogen can ensure a better matching of nitrogen applications to the optimal rates which gradually become known as the season and market conditions unfold. A precursor to nitrogen applications is matching the variety to the likely length of season and paddock conditions.

Switch to crops with better gross margins

The marked changes in crop prices and bag nitrogen mean that farmers should undertake or seek advice on analyses of gross margins of their main crop options. Comparing barley versus wheat, canola versus wheat and comparing returns from production of different grades of wheat are all examples of site-specific analyses that will assist a farmer to make sound decisions based on profit considerations. Often decisions will result in less use of bag nitrogen, assuming seasonal conditions are not highly favourable. Some decisions will involve switching away from enterprises such as canola that may require large expenditures on inputs for an uncertain return.

Low-cost management of poor paddocks

The forecast very poor returns from cropping on some paddocks in 2005 makes retirement of these paddocks sensible. Depending on the nature of the paddock and the farm's existing mix of enterprises it may be preferable to green manure or establish an annual or perennial pasture. Either way the opportunity cost of these paddocks not being in crop in 2005 is likely to be very low.

Farming system review

Some crop enterprises in some situations are under threat from herbicide-resistant weeds, crop diseases and pests, high input costs (fixed and variable) and much-reduced profit margins. The high price of nitrogenous fertilisers is only one of several changes sapping farm profit. For some businesses it may be necessary to review their farming system and make enterprise and investment adjustments that better protect the longer-term profitability of the farm business.

Low-cost learning for diversification

With low profit margins on many crops it is feasible to trial a paddock of new crops (e.g. serradella, field peas, faba beans, chick peas) to learn how to grow these crops. The opportunity cost of switching a paddock of feed barley or wheat into one of these new crops is unlikely to be high. The goal is to learn how to manage these new crops. First-time growers need to ensure their paddock selection and management regime is technically correct. However, growers should not over-commit land and resources (including time) to growing these new crops.

An illustration of impacts

Representative farm modelling for the eastern wheatbelt shows that if season 2005 is an average season then the increase in costs (e.g. bag nitrogen) and lower prices for all grains will hugely lessen farm returns. There is a large incentive to switch more resources into livestock (mostly lamb) and wool production. Less nitrogen is applied to crops and fewer paddocks are put into crop.

However, in practice, the wisdom of additional investment in a sheep enterprise is conditional on a host of factors such as the buy-in price, pasture availability, state of sheep handling infrastructure and sheep knowledge and skill of the farmer. For many farmers it would be a waste of money, or a poor investment, to rush out and make a massive new capital commitment to sheep and wool production.

Table 2. 'Optimal' farm plans for a typical eastern wheatbelt farm*

Farm plan	Unit	Season 2004*	Season 2005*
Farm net return	$'000	102	-1 to 17
Crop area	% of arable area	58	38 to 47
Cereal area	ha	2,090	1,425 to 1,715
Canola area	ha	95	0
Grain fed	tonne	68	85 to 98
Sheep numbers	dse	7,920	10,320 to 12,069

* Based on an average season, typical prices and costs for 2004 and forecast prices and costs for 2005.

CONCLUSION

Although climate prospects appear sound for season 2005, grain and nitrogenous fertiliser prices are not attractive. The heightened cost-price squeeze in season 2005 should lead many grain growers to focus on cost control with careful management of crop production, including fertiliser use. In general, tactical use of nitrogen fertilisers is warranted. Overall, less use of nitrogen fertilisers may be justified in many situations, as may less cropping. Switching of crop types (e.g. wheat for feed barley) and varieties may be needed. Where warranted a greater emphasis may be placed on livestock production. The low cost set-up of marginal paddocks for season 2006 may also be required.

KEY WORDS

nitrogen, fertiliser, grain prices, profit

Paper reviewed by: Bill Bowden

Stubble management: The short and long term implications for crop nutrition and soil fertility

Wayne Pluske, Nutrient Management Systems and **Bill Bowden**, Department of Agriculture, Western Australia

KEY MESSAGES

Your choice of stubble management technique can have major effects on the long-term soil fertility of a paddock and the short-term nutrient availability for the next crop.

You need to analyse stubbles if you want to accurately budget nutrients in your system and quantify costs of your stubble management decisions. For a cost of about $160/paddock to analyse stubbles you can easily gather information that could help decisions worth $60–70/ha.

AIMS

To highlight the importance of stubble management choices on soil fertility and nutrient availability.

BACKGROUND

About 7 million hectares of stubbles are managed each year in WA. They are baled, burnt or kept and/or grazed. The choice of management depends on a lot of factors from tractability at seeding, through desires to improve soil fertility, to things like disease, pest and weed control. The decision maker/manager needs to know the implications of any management choice he makes for any and all of these factors.

Here we outline some of the implications for soil fertility and crop nutrition of the ‘keep’, ‘bale’ and ‘burn’ management options. Despite the inadequacy of the available data to do this, we have tried to make quantitative estimates of the losses and costs of nutrient transformations.

RESULTS

The long-term budget = amounts of nutrients in stubbles

It is a simple matter to estimate the amount of nutrient in a stubble used for whatever purposes as long as you have some feel for the nutrient concentration in the stubble and the quantity of that stubble. Thus 2.1% N in the stubble means 21 kg N/t of stubble before implementation of any management option.

Stubbles vary markedly in their nutrient content depending on factors like crop type, soil type, fertiliser history and growing season conditions. An example of this variation is in the table below. Using K as an example, in 3 t/ha of stubble the quantity may vary from 21 to 77 kg/ha, which represents a difference of about $45/ha. Analysing stubble to measure K, rather than using an assumed concentration could better quantify the K dollars involved in stubble management decisions by $20/ha.

Element	Low	Mean	High
Nitrogen (%)	0.16	0.51	1.15
Phosphorus (%)	0.02	0.05	0.15
Potassium (%)	0.69	1.28	2.55
Sulphur (%)	0.08	0.13	0.21
Calcium (%)	0.10	0.18	0.38
Magnesium (%)	0.09	0.15	0.26
Copper (mg/kg)	3	6	12
Zinc (mg/kg)	3	7	27
Manganese (mg/kg)	16	41	78

Survey (42 sites over 5 seasons), Schultz and French, 1976.

We will use average figures and concentrate on wheat information for the discussion below.

The short-term budget = the availability of nutrients left on the paddock

The next problem in estimating the dollar value of nutrients in stubble is determining the chemical or plant available forms of the nutrients once their quantities are known.

If a stubble is **retained**, some nutrients (K and S) can come out of the stubble and into the soil in a plant available form with very little input of rain. Other nutrients (N, P, S, Ca, and trace elements) require the breakdown of stubble before they are released, and the rate at which this happens varies markedly with how the retained stubble is managed. For example, if stubble remains vertical, breakdown is slow. If it is incorporated into the soil and conditions are warm and moist, then breakdown can be quite rapid.

If a stubble is **grazed**, these breakdown processes are speeded up in the microbial vat of the rumen. However nutrients are redistributed to concentrated urine and faeces zones, which render them less available to all but the adjacent plants in the next crop.

If a stubble is **baled**, all the nutrients in the baled stubble are removed. The moot point is how much is in the stubble at the time of baling because some leaching to the soil may have occurred between harvest and baling. Again this emphasises the need to analyse stubble if genuinely concerned about the value of nutrients removed.

If a stubble is **burnt**, then some nutrients (e.g. N and S) go off as gases while others form unavailable compounds in the ash. To add to the difficulty of estimation, unknown quantities of minerals in the ash can be lost as smoke or in subsequent wind erosion events. Burning with fire is an oxidation process that creates metal oxides of the cations and these oxides can have a quite rapid liming effect. Soil microbes also oxidise the stubble with similar effects except that they retain/immobilise stubble N while flames can cause greenhouse active nitrous oxide to be lost from the system.

The table below contains calculated estimates of the long and short-term nutrient values and nutrient costs of different management options for a 3 t/ha stubble. Inherent in the calculations used are average values of nutrient contents in wheat stubbles and plant availabilities in stubble and ash. It is assumed that there is no loss of ash after burning, that there is no redistribution through grazing of nutrients in retained stubbles and that 80% of straw is baled.

	Long term nutrient value ($/ha)	**Short term nutrient value for next crop ($/ha)**
In stubble	49.40	23.60
After baling	9.90	4.70
Cost of baling *	39.50	18.90
After burning	34.10	25.80
Cost of burning *	15.30	-2.23 (benefit)

* Compared to retaining stubble.

Assumed value of nutrients: $0.85/kg N, $2.30/kg P, $0.80/kg K, $0.10/kg S, $0.02/kg Ca, $0.12/kg Mg, $7/kg Cu, $2.20/kg Zn, $2.20/kg Mn, $0.01/kg lime. More details of assumptions behind these calculations are in Pluske and Bowden, Dec. 2004, Farming Ahead with Kondinin Group.

CONCLUSION

Stubble management can have costly nutrient implications. These are difficult to accurately determine unless stubbles are analysed in a laboratory. The time and cost required for sampling and analysing stubbles is very cheap compared to poor stubble management decisions made without any accurate knowledge of the quantity and value of nutrients involved.

KEY WORDS

stubble, nutrients, potassium, bale, burn

Paper reviewed by: Mike Collins, WANTFA

Stubble management: The pros and cons of different methods

Bill Bowden, Department of Agriculture, Western Australia and **Mike Collins**, WANTFA

KEY MESSAGES

In general there is no 'best' way to manage stubbles, though there can well be a best way for any given circumstance.

Growers should look at what management is practical for their set-up and farming system and then review in the light of the consequences for other factors which will be affected by it.

Rather than offering optimum stubble management packages, researchers and advisers should outline the options for, and consequences of, different management practices in specific situations.

AIM

This paper highlights the importance and effect of stubble management choices on a range of production and environmental factors.

BACKGROUND

About 7 million hectares of stubbles are managed one way or another, in WA each year.

Growers have many different stubble management options at their disposal including: burn, retain, incorporate, rake and sell, spread or windrow, collect in chaff carts, graze, cut high or low and some combinations of these. The actual choice made is usually (and rightly) specific to the nature of the stubble, the nature of the equipment the grower has for harvesting and seeding, and the individual's perception of the stubble management related problems he/she has to deal with. The choice of stubble management technique is often made on the basis of one factor alone.

However, the management choice taken can have major effects on a range of factors. These include: tractability at seeding, water relations, soil chemical, physical and biological fertility for both the short and long term, wind and water erosion, pest, weed and disease levels, herbicide effectiveness, seed banks, pasture re-establishment, summer/autumn grazing, animal nutrition, agronomics, economics and even sociology.

In this paper we outline some of the pros and cons of different management techniques. The growers need to weigh them up according to their individual circumstances.

DISCUSSION

The pros of one management method are often the cons of another. Many of the pros and cons of retaining stubbles (for example) are common to methods such as baling. Different management options can be combined to minimise risks and maximise benefits.

Retaining stubble

PROS: The retained stubble sometimes harvests and concentrates rainfall and can create a mulch and so can help retain water. Keeping the OM helps build soil organic carbon albeit nowhere near as fast as some people think. It provides a protective surface against wind and water erosion and reduces soil splash delivered diseases. All nutrients and 'lime' in the stubble is retained. Stubbles can physically reduce weed establishment. Stubbles can be used as a source of energy for animal nutrition and also for soil microorganism function.

CONS: The retained stubble can prevent light rain reaching the soil. It can cause the tie up and reduce the availability of soil and fertiliser nitrogen. It can maintain the spore loads of some leaf and stem diseases of crops. It only slowly recycles some nutrients and 'lime'. Heavy stubbles can cause problems with blockages and 'hair-pinning' at seeding unless (costly?) adjustments are made to

harvesting and or seeding machinery. Stubbles can affect seedling emergence and establishment, particularly for pasture re-establishment where wilting diseases can be a problem. There can be vinegar effects on seedlings when there has been no weathering over summer/autumn. Heavy stubbles can harbour pests (mice, snails, webworm). Ground cover can reduce the effectiveness of some herbicides.

Burning stubble

PROS: Burning at the right temperatures can effectively destroy weed seeds. Burnt stubbles are easy to negotiate at seeding. The ground cover is not there to reduce herbicide effectiveness. The lack of stubble allows good seed to soil, and fertiliser to soil, contact. Burning significantly reduces disease spore loads and havens for pests. It makes the liming effect more immediate and rapidly release most recycling nutrients. Burning high C:N material increases the short-term availability of N.

CONS: Raises the risks of wind and water erosion. Reduces the water retaining benefits of stubble mulches. Causes absolute losses of N and S as gases, with nitrous oxide being very greenhouse sensitive. Slows the rate of soil OC% increases. Intense burns of long duration (e.g. chaff cart heaps) can volatilise soil OM and create non-wetting soils.

Other practices

Baling and selling stubbles has the advantage of earning a quick dollar provided the stubble is good quality with low contamination. This can help cash flow and allows easier seeding. However it removes all the nutrients and 'lime' in the stubble and can expose the soil to erosion risks. *Grazing stubbles* obviously feeds sheep, but trampled stubble is more difficult to sow into than upright stubble. Sheep bury seeds and can cause an earlier germination, which can improve weed control, but the hooves detach soil which can increase the erosional risk. *Chaff carts* can catch seeds and reduce weed burdens, but redistribute nutrients to small areas. Burnt heaps of chaff can cause salting and wettability problems for a season or two.

Machinery adjustments

In WA, with the appropriate machinery adjustments, it is now technically possible to retain all stubbles. You can choose your cutting height and straw distribution patterns at harvest and even mow the stubbles later. Below 3 t/ha, stubbles are not a great problem with modern seeding rigs where there are at least 5 ranks of tines; the tine layout has been optimised for low clumping and a wider row spacing (such as 25 or 30 cm) is used. Above 3 t/ha, there are means of improving seeder performance, such as fitting stubble tubes, coulters or residue management wheels. In 2004, those with 2 cm accuracy auto steer on their tractors were able to sow between the rows of heavy stubble from 2003 and virtually eliminated clumping and the effect this has on crop establishment.

CONCLUSION

How you handle your stubbles depends markedly on your individual perception of the problems and the machinery and stock you have to handle them. You can overcome many of the seeding problems with appropriate adjustments to seeding and harvesting machinery. You can improve weed control with less risk of erosion by burning in controlled windrows and chaff heaps. You can increase the rate of stubble breakdown by getting it onto or into moist soil.

There are times and situations when it might be appropriate to burn stubbles such as particularly heavy crops when your machinery set up is not appropriate, or when you have major disease pest or weed burdens.

Keep your management options open but do not forget that there are many implications for any chosen course of action.

KEY WORDS

stubble management, bale, burn

Paper reviewed by: Linda Leonard, Department of Agriculture

Effect of stubble burning and seasonality on microbial processes and nutrient cycling

Frances Hoyle, The University of Western Australia

KEY MESSAGES

The amount, type and management of plant residues can affect both the timing and amount of nutrients supplied (N, S, P) to the crop, by changing the activity of microorganisms in soil (as this is their food source). Stubble retention promoted both a larger but also more active microbial community compared to burning. Management practices such as reduced cultivation, residue retention and burning of residues can therefore have a major impact on biological soil N release to subsequent crops.

AIMS

The effect of long term stubble management is currently under investigation to identify factors influencing microbial activity, soil organic matter-c turnover and related nutrient cycling. The experimental site (established 1987, g. Reithmuller, WADA) is located on a red-brown earth (heavy clay loam) at Merredin and was used to determine the effect of stubble management on microbial processes. The site has been continuously cropped since establishment in a 2 year rotation based primarily on wheat production, and stubble either retained or burnt. In our investigation, the main aims of the trial were to assess the effect of long term stubble management and temperature (to reflect seasonal differences) on biological activity and measure microbial n supply.

METHOD

The study area was located at the Department of Agriculture Merredin Research Station (615525 mE, 6515338 mN) on a trial (established 1987, G. Reithmuller, DAWA) in the low rainfall (< 325 mm annually) region of Western Australia on a Red-Brown Earth (Red Chromosol, 26% clay content). The experiment used was in a 2 y cropping rotation based on wheat production and had been established for 17 y prior to sampling, with stubble either burnt prior to sowing or retained. Mean monthly temperature based on 17 y of climatic data (1987 to 2003) ranged from 5.6 to 34.1°C and mean annual rainfall was approximately 294 mm (Figure 1). In 2003, temperatures were in the range -1.7 to 42.2°C and annual rainfall reached 356 mm of which 190 mm fell during the winter cereal growing season (May to November).

In 2003, wheat (Triticum *aestivum* L.) cultivar 'Wyalkatchem' was sown at 110 kg/ha after adjustment for seed size and assuming a field emergence of 70%, to achieve a target density of 200 plants per m^2. The trial was sown on 7th June in a randomised block design, with various row spacing treatments and replicated six times. For the purpose of this investigation, three replicate plots were sampled from both the stubble retained or burnt treatments sown on 180 mm row spacings. All treatments were sown with a basal fertiliser of 150 kg/ha Agras (17.5% N) on narrow points with press wheels. Initial screening of a range of parameters was conducted prior to sowing to characterise the background soil fertility and biological activity of the site. Physical soil and stubble parameters included bulk density, soil moisture and water holding capacity.

RESULTS

Analyses for physical and chemical status of the soil, indicates there are no measurable constraints to yield at this site (data not presented). The total amount of above ground organic matter returned to soil in stubble retained (1.2 t/ha/y) versus burnt treatments (0.2 t/ha/y), did not increase the percentage of soil organic carbon significantly ($P = 0.05$,). However, after adjustment for bulk density a significant difference ($P < 0.09$) between treatments was measured in total soil carbon.

Soil N released from crop residues and soil organic matter results primarily from the activity of microorganisms. Therefore any change in their activity (microbial respiration; Figure 1), or their weight/mass (microbial biomass; Figure 2) can result in changes to the rate of biological soil N supply.

This has been assessed for the retained versus burnt treatments. Microbial activity (Figure 1) was found to be greater where stubble was retained, particularly at soil temperatures above 10ºC. Stubble retention also resulted in a higher mass of microorganisms in the surface (0-5 cm) layer of the soil (Figure 2) and similar amounts at greater depth.

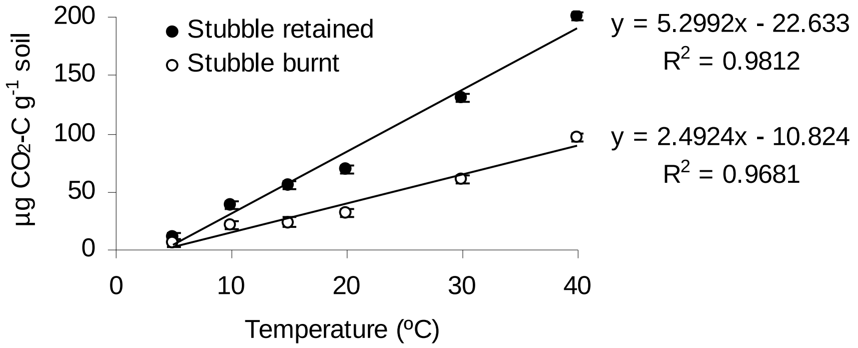

Figure 1. The effect of long term stubble management (retained versus burnt) on microbial respiration rates (CO_2-C evolved) at Merredin in 2003.

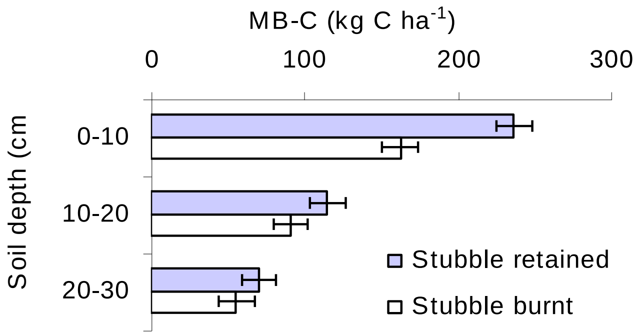

Figure 2. The effect of long term stubble management (retained versus burnt) on microbial biomass-C at Merredin in 2003.

The mass of microorganisms measured to 30 cm depth in this trial was 486 kg per ha C in stubble retained and 348 kg/ha C in burnt treatments. Microbial N was estimated at 89 and 67 kg of N per ha for stubble retained and burnt treatments respectively (data not presented). This means that there is equivalent to 146 kg/ha (stubble burnt) and 192 kg/ha (stubble retained) of Urea contained within the soil microorganisms – a significant source of potentially plant available N.

Changes in the mass of microorganisms and their activity are commonly reflected in changes to the soil supply rate of both C and N. This has been demonstrated in Figure 3 where it can be seen that at all temperatures tested, the stubble retained treatments released more soil N than the burnt treatments. Clearly these results illustrate that stubble retention promoted both a larger but also more active microbial community compared to burning.

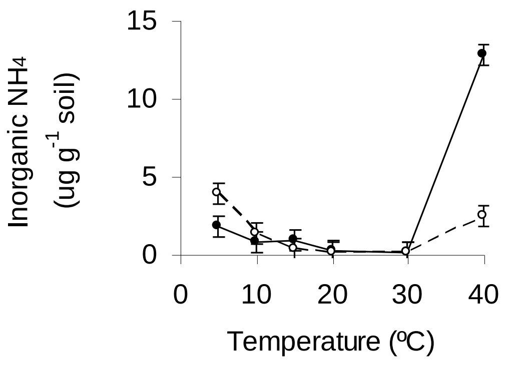

Figure 3. The effect of long term stubble management on inorganic NH_4 resulting from microbial supply in stubble retained (●) and stubble burnt (○) treatments at Merredin in 2003.

Effect of residue management on grain yield

Grain yield (estimated by hand harvest) at this site reached 3.07 and 2.28 t/ha for stubble retained and burnt treatments respectively. Grain protein was measured at 9.5% (retained) and 11.0% (burnt). This indicates an N uptake in above ground plant material of approximately 292 kg/N/ha in stubble retained treatments and 251 kg/N/ha in burnt stubble treatments.

CONCLUSION

Stubble retention has been shown to increase the amount of microorganisms in soil compared with stubble burning, resulting in greater soil nitrogen supply. Residue incorporation can also be an effective means of increasing biological soil nitrogen supply and potential grain production. However, potential yield depends on the ability of the subsequent grain crop to utilise this inorganic nitrogen, and is therefore influenced significantly by both rainfall pattern and intensity as this will alter the location of inorganic nitrogen in the soil profile compared with plant root development. Management strategies to optimise the synchrony between nutrient release and crop demand must therefore be considered.

KEY WORDS

stubble, burning, carbon, nitrogen, microbial

ACKNOWLEDGMENTS

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Project No.: UWA395

Paper reviewed by: Justine Cox

NB: There is an extended version of this paper on the Crop Update 2005 CD.

Soil biology and crop production in Western Australian farming systems

D.V. Murphy, N. Milton, M. Osman, F.C. Hoyle, L.K Abbott, W.R. Cookson and **S. Darmawanto**, The University of Western Australia

PAPER OVERVIEW

Agricultural management practices ultimately seek to optimise plant and animal productivity within the overriding constraints of both climate, and the capacity of the soil (physical, chemical and biological attributes) to support plant growth. Whilst optimal physical and chemical conditions of the soil for plant growth are often well defined, we have a much poorer understanding of the control that biological factors, particularly non-pathogenic associations, have on plant growth. The objective of this paper is to examine the relative contribution of soil biological attributes to crop production in Western Australian farming systems. Once these key attributes have been identified, management practices can be selected that take into account the potential for enhanced soil biological fertility and improved yield. Where potential yield is not achieved our approach has been to assume that this is the result of inappropriate management practices and/or soil physical, chemical or biological constraints to crop production (Figure 1).

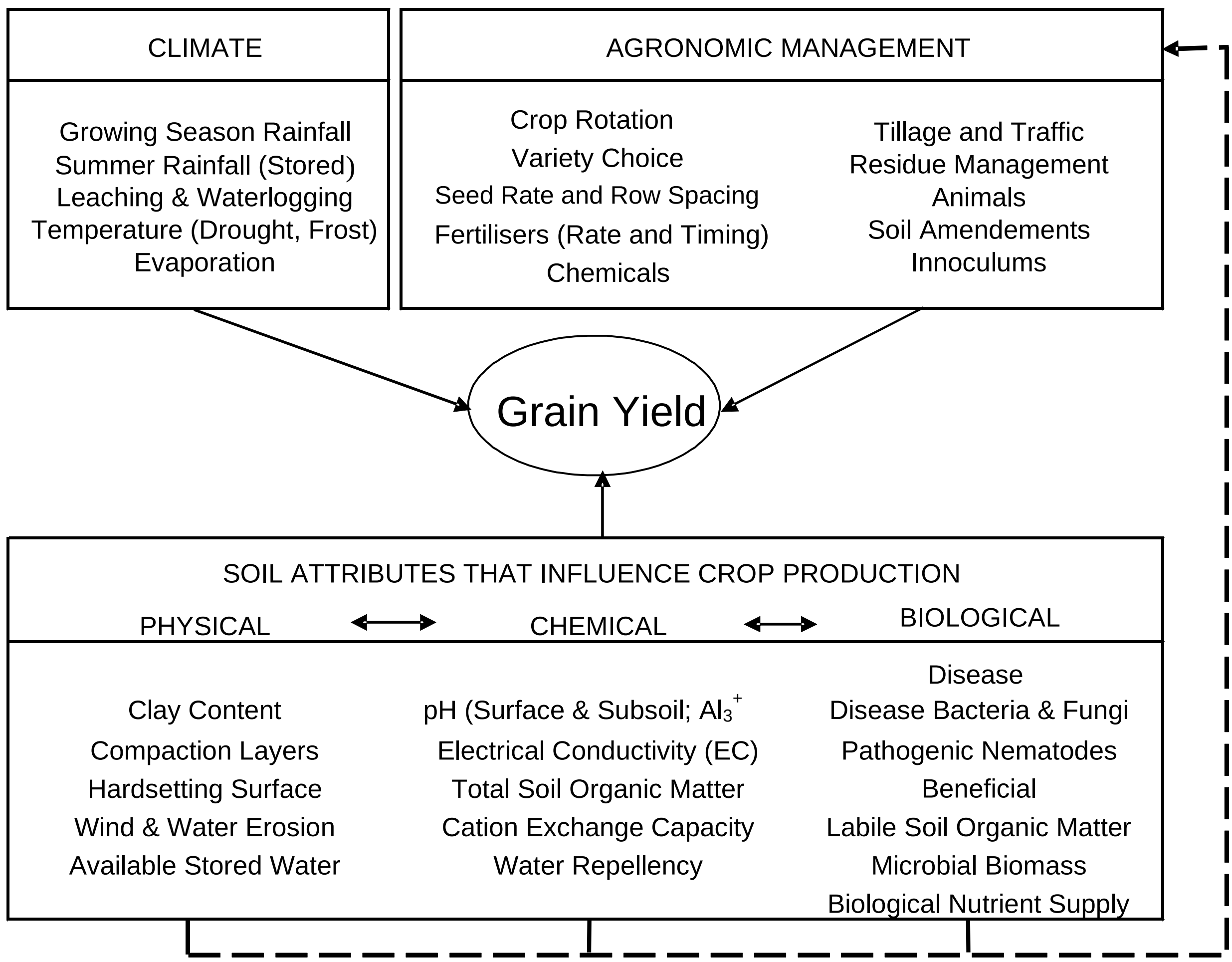


Figure 1. Climatic and agronomic factors along with key soil physical, chemical and biological constraints to yield production in Western Australian farming systems – A conceptual model.

Once soil constraints are identified their economic importance can be assessed (i.e. cost and practicality of removing the constraint versus potential yield benefit) prior to implementing changes in agronomic practice. This approach focuses on discrete soil attributes that: (i) have a known direct impact on crop production; and (ii) can be measured and interpreted in the context of management

solutions. This approach provides an economic evaluation of 'cause' and 'effect', enabling prioritisation of high return solutions to overcome major agronomic and soil limitations instead of placing effort in further detailed site characterisation which is not feasible over a large scale.

Evaluation of the 'soil indicator' package described in the figure above was achieved by collecting climatic, agronomic and soil data from 40 paddocks (20 farms) in two adjoining catchment groups within the York-Beverley-Quairading farming region (named 'A' and 'B' for simplicity). Actual yield data from the 40 paddocks illustrate that on a site by site basis actual yield can vary considerably (mean = 2.5 t ha^{-1}; min = 0.44 t ha^{-1}; max = 4.74 t ha^{-1}) within a small range in growing season rainfall. Combinations of significant factors (from those listed in the figure above) that influenced grain yield were then determined using ordinary least square multiple regression analysis. Removing attributes that were either directly related to the mass of microorganisms (microbial biomass), or those that were not significantly affecting grain yield, resulted in the development of a simple schematic model to explain the variability in grain yield (Figure 2). This model, which consisted of growing season rainfall, N fertiliser and microbial biomass as the only 3 attributes used explained 40% of the variability in grain yield. It is worth noting that microbial biomass explained the greatest contribution of grain yield variability at 30%. Further analysis indicated that the influence of the microbial biomass on yield was predominately due to the strong relationship (r^2 = 0.77) to biological nitrogen supply. Thus the model used to describe grain yield could alternatively be expressed as growing season rainfall, N fertiliser and biological nitrogen supply with a similar percentage of the grain yield still being explained (data not shown). This provides a simple water and N availability story as the key drivers of grain production in this environment which is supported by the fact that water is essential for plant growth and that N is the primary nutrient limiting crop production throughout the world.

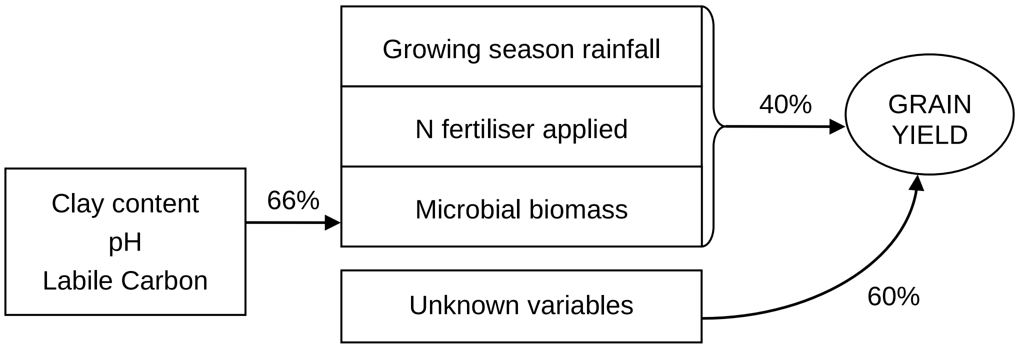


Figure 2. A schematic representation of the multiple regression analysis models used to describe microbial biomass (explanatory variables: nlogClay content*pH*Labile Carbon) and grain yield (explanatory variables: Growing season rainfall*N fertiliser applied*Microbial Biomass).

CONCLUSION

Soil biological fertility was significantly correlated to grain production in WA. The benefit was predominately associated with the size of the microbial biomass, which was directly related to their capacity to decompose soil organic matter and fresh residues to release plant available N.

ACKNOWLEDGEMENTS

This research is funded by the Grains Research and Development Corporation with support from The University of Western Australia. We also thank growers from the catchment groups for their participation in this research.

Paper reviewed by: Matthew Braimbridge and Tamara Flavel

NB: There is an extended version of this paper on the Crop Update 2005 CD.

Urea is as effective as CAN when no rain for 10 days

Bill Crabtree, Crabtree Agricultural Consulting

KEY MESSAGES

When urea or calcium ammonium nitrate (CAN) were applied at the same N rate to Mundah barley 4 weeks after sowing, the yield response to urea was twice that of the CAN when the nitrogen (N) was applied just prior to a 27 mm rainfall event. Surprisingly, when these N fertilisers were applied after the rain and no rain fell in the next 10 days, the urea still performed as well as the CAN in terms of grain yield. With both timings, with respect to rainfall, the urea was economically better than the CAN where more than 20 kg N/ha was applied giving up to an extra $110/ha return.

AIM

To determine if CAN has a niche to perform better than the urea in the absence of eminent rain and on a moist soil surface for barley production in Western Australia.

METHOD

A field trial with control plots every third plot was used to compare 4 rates of CAN (0, 20, 39, 59 kg N/ha) against 4 rates of urea (0, 26, 52, 78 kg N/ha) and this was done at two timings. The timings were either the day before 27 mm of rain (6 July) or three days after this rain with no rain for the next 10 days (then 10 mm fell). The timing treatments were separated in space (adjacent) and therefore can not be precisely compared to each other. All treatments were replicated twice. The plots were 15 m long by 2 m wide.

Mundah barley was no-till sown at 70 kg/ha on 250 mm row spacings on 15 June 2004 with 12.5 kg P/ha, 5.5 kg S/ha and 10 kg K/ha and a further 30 kg K/ha was topdressed 4 weeks after sowing. Nitrogen was applied by hand when the barley was at 3-3.5 leaf stage on 6 July (on dry soil before the rain) and on 10 July on moist soil.

Sap nitrate uptake data was measured with the Nitraquik test kit on 10 and 22 July and 5 August. Grain yield was collected with a mechanical harvester on 19 December 2004 and protein was measured by CBH for each plot. Grain yield was analysed spatially.

The site was very N responsive, as it had grown a good wheat crop in 2003, a poor lupin crop in 2002 (drought) and a good wheat crop in 2001. The soil was sandy to at least 40 cm depth and the western end (second N timing) was lower yielding.

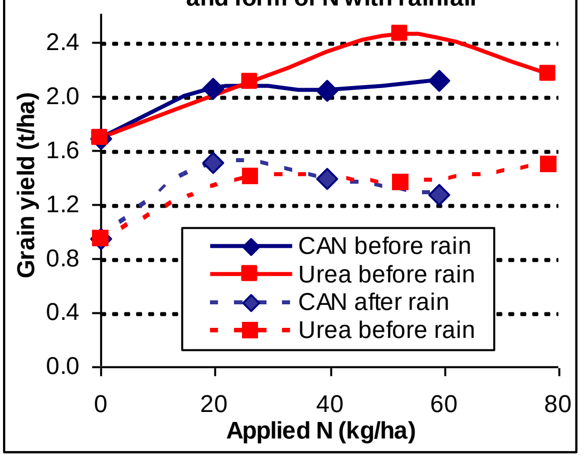
RESULTS

There was an increase in grain yield when N was applied before or after the rainfall event (Figure 1). The greatest N responses were with urea applied before the rain (and on the better soil).

When N was applied before rain, urea at the higher rates, yielded 400 kg/ha more than CAN. When N was applied after the rain, and on a moist soil surface with no rain for the next 10 days, yield was similar per unit of applied N for both CAN and Urea, but at a greater cost per unit of N for CAN.

N removal in harvested grain gave similar results to the grain yield (Figure 2), the one exception being that CAN gave better N uptake efficiencies than urea at the low rate of 30 kg N/ha at both timings. But this was no more economical than the urea.

Figure 1: Barley grain yield with timing and form of N with rainfall



The plant sap nitrate tests showed that CAN, applied before the rain, was taken up within 4 days of being applied (data not shown). The second sap test (Table 1) taken 12 days after the first N was applied (and before the rain) on 22 July showed that CAN and urea gave similar uptakes (for similar N applied) being up to an 8-fold increase over the control [3.4% N {Leco} a CSBP test]). While the CAN applied after the rain gave modest N uptake and the urea gave poor early N uptake. Within two weeks this later applied urea gave equal plant N uptake as all other CAN and urea treatments.

Table 1	**Sap nitrate from *CAN* (g/kg)**			**Sap nitrate from *urea* (g/kg)**		
kg N/ha	**N timing**	**22 July**	**4 Aug.**	**kg N/ha**	**22 July**	**4 Aug.**
0	before rain	240	320	0	220	200
20	before rain	540	640	26	480	580
39	before rain	1160	1400	52	960	1160
59	before rain	1680	2380	78	1640	1760
0	after rain	240	200	0	260	220
20	after rain	640	780	26	280	400
39	after rain	880	1120	52	320	740
59	after rain	800	1400	78	340	1300

CAN never performed better than urea in terms of profits generated. At all N rates, except 20 kg N/ha, the urea gave large economical benefits over CAN. This was from $40-110/ha (Figure 3). These calculations are based on: a) barley @ $140/t farm gate price; b) CAN @ $440/t; c) Urea @ $420/t; d) other costs to grow the crop are $190/ha; and e) there were no differences in grain quality (assessed from grain samples).

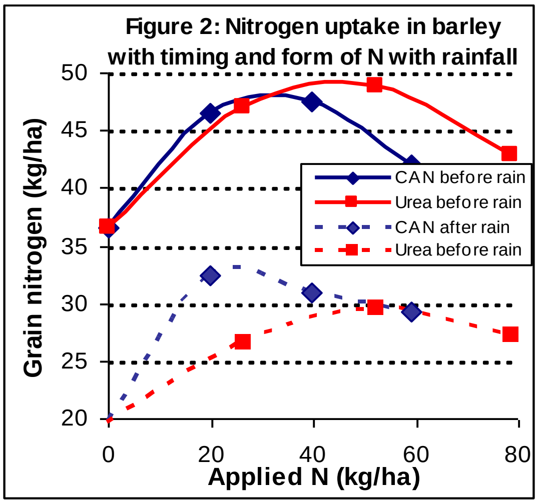


Figure 2: Nitrogen uptake in barley with timing and form of N with rainfall

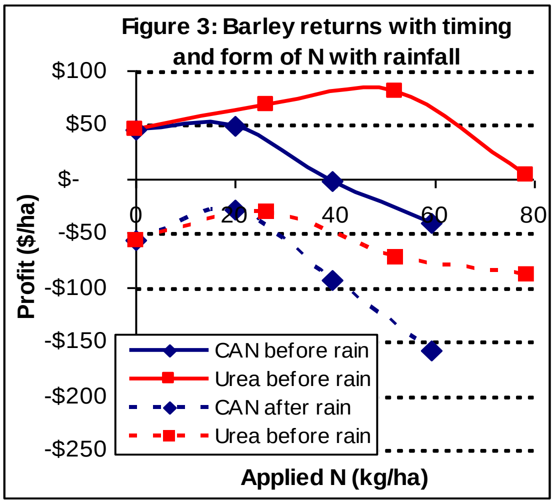


Figure 3: Barley returns with timing and form of N with rainfall

CONCLUSION

Caution is urged with this single trial data set as it needs to be compared to other data generated independently by non fertiliser companies. The data is however consistent with three 1999 WANTFA trials which showed that urea gave much greater economic responses than CAN.

These data suggest that urea was superior to CAN when applied before a rain event. Interestingly, urea gave similar grain yield responses, but superior economics, to CAN when it was topdressed onto a moist soil surface without any rain for 10 days. This is a sobering data set for those farmers and the promoters of CAN who believe that it is superior to urea if applied when rain is not forecast within 7-10 days. This data suggests that, in our cool agricultural climes (3-17^{O}C range), when urea is topdressed on the soils surface that losses to volatilisation are perhaps small (given how it compared to CAN). Research into exact N losses from urea in these conditions is encouraged.

KEY WORDS

CAN, calcium ammonium nitrate, urea, N, nitrogen, timing, rainfall, volatilisation, barley, grain yield

ACKNOWLEDGMENTS

Todd Quartermaine for proving the site, pegs and assisting with the first topdressing of nitrogen. HF DeWet for taking the third SAP nitrate test. Peter Dixon for topdressing potash over the whole site. Jonathan Crabtree for topdressing the second nitrogen treatments. Peter Carlton for harvesting.

Paper reviewed by: Peter Carlton, Elders Trials Coordinator

Fertiliser (N, P, S, K) and lime requirements for wheat production in the Merredin district

Geoff Anderson, Department of Agriculture and **Darren Kidson**, Summit Fertilizers

KEY MESSAGES

N, P, S, K and lime are important inputs for wheat production in the Merredin district. Soil test measurement, omission experiments and detailed analysis using a Soil Management Calculator (SMCAL) are required to fully understand these soil fertility limitations to wheat production.

AIMS

1. To undertake soil test measurements and omission experiments to determine which nutrient(s) is limiting wheat production in the Merredin district.
2. To evaluate the ability of SMCAL to predict the capacity of soil to supply nutrients.

METHOD

Six field sites where selected from the Summit Fertiliser, Merredin, soil database. Four sites were located north of Merredin and two sites east of Bodallin. A nutrient omission trial was conducted at each site. The treatment included: nil (no N, P, K and S); All (plus N, P, K and S); All + silvine (plus N, P, K, S and silvine); All-N; All-P, All-K and All-S. Nutrients were applied at 70 kg N/ha, 10 kg P/ha, 50 kg K/ha, 15 kg S/ha and 70 kg silvine/ha.

Silvine is a product under evaluation in WA, SA Vic and NSW. It contains, 4% soluble silicon as monosilicic acid and 5% soluble magnesium as magnesium sulphate, and thus has the potential to give a magnesium or silicon response. Research and other trial work is suggesting that it increases the plant uptake of the fertiliser P.

At site 3, 4, 5 and 6 these treatments were repeated on minus and plus lime (2 t/ha) treatments. The All treatment was replicated 4 times with a single replicate used for the remaining treatments. Wheat was sown with no fertiliser input using the farmer's equipment. The nutrient treatments were then top dressed onto plots after sowing.

Soil was collected in layers to a depth of 0.5 m at sites 1-3 and to 0.9 m at sites 4-6 in May 2004. Soil sample where measured for; NO_3^-, NH_4^+, bicarbonate extractable P and K, KCl_{40} extractable S, organic carbon, 0.01 M $CaCl_2$ soil pH, extractable Al, and phosphate retention index.

Maximum biomass was measured by collecting plant samples from 1 m lengths along two rows in September. Grain yield was measured by collecting plant samples from 1 m lengths along four rows in November and the grain was separated from the straw. These samples were then oven dried (2 days at 80^{o}C) and dry weights measured.

RESULTS

Annual rainfall at Merredin was 276 mm in 2004. This was less than the long term average of 326 mm. Rainfall was equal to or greater than the long term monthly averages during April, May, June and August but 13-73% less than average during July, September and November. These seasonal conditions resulted in crops producing high amounts of biomass (Table 2) but relatively low grain yields (Table 3).

Table 1. Sites 0-10 cm soil layer soil measurements of the various sites before sowing

Site	Soil type	C%	NO_3 ppm	NH_4 ppm	pH	S ppm	PRI	P ppm	K ppm
1	Sandy Loam	0.32	11	1	4.8	12.6	6.5	33	112
2	Loamy Sand	0.83	14	1	5.2	11.5	9.5	30	155
3	Sandy Gravel	0.61	15	2	4.3	40.8	37.4	10	61
4	Deep Yellow Sand	0.84	7	2	4.4	12.1	17.5	16	19
5	Deep Yellow Sand	0.76	5	1	4.9	4.9	7.6	15	45
6	Deep Yellow Sand	0.96	4	1	5.2	6.0	7.7	16	43

Site 1 had low soil carbon indicating a low capacity of the soil to supply N and S (Table 1). Site 2 has had wheat crops grown in the previous 3 years. Site 3 had low pH, low soil P and high PRI. Site 4 had low soil K levels and low soil pH. Sites 5 and 6 are located on the same farm with wheat grown at both sites in 2003. Soil S and K levels were low at both site 5 and 6.

Biomass production ranged between 1.1-6.3 t/ha (Table 2). All sites were responsive to nutrient inputs with dry weight/yield increases of 14-58%. An exception was for the minus lime treatment at site 4. Also at site 3 wheat biomass production was only 0.3 t/ha and did not respond to either nutrient or lime inputs (data not presented). In 2005, it is planned to conduct an experiment at site 3 to examine management strategies to improve wheat response to nutrient and lime inputs. Wheat biomass responded to omitting N at five sites (11-65% decrease), to omitting K at three sites (21-35%), to omitting P at three sites (19-30%) and to omitting S at three sites (11-20%). A lime response was measured at site 4 while no response was measured at site 5 and 6 (data not presented).

Table 2. Spring biomass production (t/ha) measured at each site for the nutrient and lime treatments

Sites	Lime	All	Nil	All + silvine	-K	-N	-P	-S	STDEV
1		6.3	5.4	6.0	6.3	5.6	4.6	5.3	0.8
2		4.0	1.9	4.1	3.1	2.0	2.8	3.2	0.7
4	- Lime	1.4	1.7	2.0	1.2	1.2	1.4	1.4	0.3
4	+ Lime	2.1	1.3	1.8	1.7	1.9	1.7	1.9	0.2
5		2.9	1.2	3.1	2.8	1.3	3.0	2.9	0.3
6		2.5	1.1	2.0	2.4	1.1	2.5	3.2	0.4

Grain yield ranged between 0.6-2.4 t/ha (Table 3). All sites sampled were responsive to nutrient inputs (11-35%). A lime response was observed at site 4. N response ranged between 15-45% at sites 2-6. At site 1, there was no N response possibly due to N input carried over from lupin in 2003. The size of the N response in grain production was smaller than the N response by the biomass due to below average spring rainfall. The K response was 21-25% at three sites. The P response was 9-15% at three sites. The S response was 11-24% at three sites. The size of the K, P and S responses was similar for both the biomass production and grain yields. Silvine gave responses at site 4, 5 and 6, which were on the deep yellow sand soil type.

Table 3. Harvest grain yield (t/ha) at each site for the nutrient and lime treatments

Site	Lime	All	Nil	All + silvine	-K	-N	-P	-S	STDEV
1		1.6	1.3	1.8	1.6	1.8	1.8	1.5	0.3
2		1.6	1.4	1.8	1.2	0.9	1.7	1.4	0.4
4	- Lime	0.9	0.6	1.0	0.7	0.6	0.8	0.8	0.2
4	+ Lime	0.9	1.0	1.3	0.9	0.8	0.4	0.7	0.2
5		1.6	1.1	2.1	1.8	1.3	1.4	1.6	0.1
6		2.1	1.4	2.4	1.6	1.8	1.8	2.4	0.1

CONCLUSION

N, S, P and K are important nutrients for wheat production in the Merredin district. The omission trial design defines the relative important of these nutrient inputs and is being used to evaluate SMCAL.

KEY WORDS

nitrogen, sulphur, phosphorus, potassium and lime

ACKNOWLEDGMENTS

Sandy Alexander (Summit Fertilizer) assistance in organising soil samples analysis was greatly appreciated. Trials were conducted on the properties of Mr Giles, Mr McGinnus, Mr Alvaro, and Mr Maddock. Their assistance made it possible to conduct the trials.

Paper reviewed by: Richard Bell

Trace element applications: Up-front versus foliar?

Bill Bowden and **Ross Brennan**, Department of Agriculture, Western Australia

KEY MESSAGES

It is best to supply trace elements to a crop to a zone in the soil which is moist for as long as possible.

Foliar trace element applications must be timely and effective. Zinc and molybdenum should be taken up before the end of tillering, manganese can be useful as late as early stem elongation and copper can still have an effect when applied as late as ear emergence.

AIM AND BACKGROUND

To provide information on trace element (TE) fertilising practices for crops. These TEs include: copper (Cu), zinc (Zn), manganese (Mn) and molybdenum (Mo)).

There has been a resurgence in interest in the use of TEs in the past few years. This is partly due more to TE deficiencies being diagnosed early in the season following early, post-seeding droughts. There has also been a demand side increase in the need for TEs associated with higher yielding seasons. Specifically, copper deficiency has been observed in high yielding crops on soils where it had not been seen before. Finally there is an increased availability and use of TE fertiliser mixes, specifically as liquid brews. The desire for 'canopy management' or 'demand feeding' with foliar applications of nutrients is also part of this renewed interest in the TEs.

DISCUSSION

Up front versus post seeding fertiliser applications

Ideally we should not have to worry about the timing or method of applying post-seeding fertilisers of any sort. A fertile soil would have adequate supplies at all times for all stages of crop growth and demand. On an infertile soil we should be able to apply fertilisers 'up front' (at sowing) and turn it into a fertile soil. However, up front applications can cause toxicities to seedlings (e.g. too much salt in a drying seed bed). They can also result in losses of availability through time (e.g. leaching of N or positional unavailability in dry surface soils of P and TEs). Nitrogen can even cause too much early growth resulting in haying off later in the season (a part of the rationale for 'canopy management').

Sometimes our pre-seeding diagnostic techniques are inadequate and we only pick up nutrient deficiencies once the crop is growing. Is there still time to correct the deficiency and how we can best do this (soil vs. foliar uptake)?

The answers to such questions depend on the role of, and demand for, the nutrient in the plant. We also have to consider the mobility of the nutrient in the soil as well as the timing and the practicalities, of application and uptake.

Crop demand and the role and mobility of nutrients in the plant

All essential elements are required at some level at all times during the growth of crops. The pattern of these requirements varies with the role(s) of nutrients and their mobility in the plant. Elements like nitrogen (N), phosphorus (P), potassium (K) and magnesium (Mg) are mobile such that the uptake for early growth can move to the growing points from older tissue if supply becomes inadequate at a later stage of growth. Copper (Cu), zinc (Zn), sulphur (S), molybdenum (Mo) and iron (Fe) are variably mobile around a plant depending on the supply and demand conditions. For example, one reason for an emerging Cu deficiency problem on country which never showed it before, is that not only has the demand gone up as yields have increased, but also, Cu moves around the plant as an amine complex. This means that while the N status of a crop is low, Cu will move out of old tissue to the new tissue with the N. When the N status is high (more common in current agriculture), the N does not need to leave the older leaves to supply the new growth and so Cu stays in those old leaves. If there is inadequate Cu supply from the soil, the crop will suffer from a N induced Cu deficiency. Calcium (Ca), boron (B) and manganese (Mn) are notoriously immobile in plants such that deficiencies can only be treated with new supplies directly to the tissues in question. For example, symptoms such as tipple top in canola and blossom end rot in tomatoes result from a deficiency of Ca in the tissue as a

result of inadequate calcium rich water passing through it. Ca in other parts of the plant is immobilised in structural tissue.

It is a simple task to plot the uptake of nutrients through time for a crop in any situation by taking tops harvests and analysing for the nutrients in question. 'Ideal' reference uptake curves can be obtained for conditions of adequate supplies of nutrients and soil moisture. However, these curves do not necessarily represent the demand for nutrients at critical times for crucial functions. For example cereal crops require adequate N, P, and zinc (Zn) early in the season to ensure tillering. Post tillering applications which mirror the uptake curves will be too late to meet this requirement and a reduction in yield potential may result.

Positional availability and mobility of nutrients in the soil

The availability of a nutrient in a soil depends on whether it is in dry or moist soil at the time that uptake is required. Soils dry from the top down and so if a nutrient is only in the surface and it dries out in the spring, then no matter how much is present, it will be unavailable for uptake at that time. Where background or applied fertiliser sits in a soil depends on where it is placed and whether it is mobile in the soil.

Nitrate N and sulphate S are mobile in WA soils and so can be applied to the surface and will wash into (and out of!) the active root zone of a crop. Depending on the soil CEC and concentration of applied nutrient, ammonium N, K, Mg and Ca are variably mobile. P and Mo are generally immobile in all soils except those with low PRI. In most WA soils, Cu and Mn are very immobile and stay where they are put. But the general rule is that if you want these TEs to be effective for as long as possible in WA soils, you will place them deeper rather than shallower.

So what does this all mean for 'up front versus foliar' applications of trace elements in WA?

CONCLUSION

Up front

Having adequate supplies of the TEs in soils which are moist, is the best bet because this serves the current crop at all stages of growth and development. If you think your crop will be deficient, put the TEs on as a solid fertiliser, and into the soil, at seeding. Apparently a very high proportion of NP compounds used in WA at seeding are now TE mixes. The TEs in the fertiliser will not create salt toxicities and will not induce massive extra growth to give you haying off problems later. This strategy gives you better positional availability and a better residual value than if those nutrients are left on the soil surface after spray applications and/or recycling from the tops.

Foliar

If a crop is diagnosed as deficient subsequent to seeding, then remember that you have a bit of a dilemma with foliar applications. On the one hand you want them to go on early enough for maximum effect, but on the other, most of the early sprays will end up on the soil surface where they are least effective as a supply to the crop. We have found that at booting on a wheat crop giving 2 t/ha grain yield, over 50% of a spray hits the soil rather than the canopy.

Zn should go on as a spray as soon as possible. In fact, because diagnostics for Zn are not very special, some growers contaminate their first compatible, in-crop, herbicide sprays with a dollar or two/ha of Zn as an insurance application. Even though most of the spray will end up on the soil surface, the amount which does land on the leaves can be enough to help early growth and tillering in cereals if they are otherwise deficient.

Cu sprays can be effective as late as booting because even at that late stage they can improve pollination in otherwise Cu deficient cereal crops. Mn sprays can also be effective post tillering for crops diagnosed as Mn deficient, though nothing beats having adequate available Mn in the soil.

KEY WORDS

trace elements, fertiliser, sprays, timing, positional availability

Paper reviewed by: Doug Sawkins

Fertcare®, Environmental Product Stewardship and Advisor Standards for the Fertilizer Industry

Nick Drew, Fertilizer Industry Federation of Australia (FIFA)

KEY MESSAGES

Food safety and environmental issues associated with nutrients are areas of public and consumer concern. FIFA and the Australian Fertilizer Services Association (AFSA) are working with government to develop a credible, coordinated industry response to threats to fertiliser use in agriculture.

Fertcare is a national training, quality assurance and certification program that focuses on managing food safety and environmental risks associated with fertiliser use. All in agriculture who are associated with fertiliser decisions or use can benefit from undertaking an appropriate level of Fertcare training. In future Fertcare accreditation is likely to be mandatory for some market and government sectors.

BACKGROUND

Environmental issues related to nutrients, and in particular eutrophication, are receiving increasing public attention. The Swan River and Peel Estuary are local examples but the issue is widespread with over 80% of the waterways in agricultural areas of Australia under threat. Heavy metals and other potential contaminants of fertiliser products are also subject to increasing public concern about food safety and possible environmental implications.

Soil and plant testing have come under critical scrutiny in the rural press. The apparent lack of consistency between laboratories and the lack of clear quality control for those interpreting the results will do little to improve farmer confidence in using these important tools.

Governments across Australia are responding to public concerns and acting to manage the food safety and environmental issues associated with nutrients. FIFA and the Australian Fertilizer Services Association (AFSA) are engaged with this process as responsible and credible partners with Government. The centrepiece of this partnership is the Fertcare program.

Fertcare is a national training, quality assurance and certification program focused on managing food safety and environmental risks associated with fertiliser use. It provides training to those who handle, store and apply fertilisers and to those who provide advice to farmers. It provides quality assurance for soil and plant test advisors based on recognition of competency and periodic audit. It provides quality assurance of the management of environmental risks at fertiliser storage and dispatch facilities, and provides certification of the uniformity of spread for application equipment.

AIMS

The aims of the Fertcare program are to:

- Provide high quality training that will allow participants to manage fertiliser handling, storage and application, and provide advice to customers, to ensure that food safety and environmental risks associated with fertiliser products are minimised.
- Provide an independent assessment process, under the National Qualifications Framework, and a periodic audit program for advisors who provide soil and plant test interpretations.
- Provide a program of quality assurance to ensure that premises where fertiliser is stored and despatched successfully manage associated environmental risks.
- Provide a certification program for spreading equipment that meets industry standards for uniformity of application.
- Ensure that key stakeholders, in particular the fertiliser industry, public and private advisors, government agencies, catchment management groups, and farmers understand the program and hold it in high regard.

METHOD

A training committee, that includes eminent independent scientists, has overseen the development of three levels of training and assessment. In addition to the training committee, expert review of particular sections of the training material was obtained to ensure the information is both current and comprehensive. A professional training organisation developed the training and assessment resources. Fertcare is delivered by registered training organisations under the national qualifications framework. It is available across Australia and is open to all participants in the industry.

The Accu-Spread program, developed by the AFSA and the University of Melbourne uses direct measurement of spread pattern and statistical analysis to determine the coefficient of variation for various products and spread-width combinations. Adjustments are performed to ensure that the cv. is < 15% at the desired spread width. The machine tested is then accredited to spread at that width.

Assessment and audit of soil and plant test advisors is being developed with the Australasian Soil and Plant Analysis Council (ASPAC) who also operate a laboratory proficiency program. A premises audit program is currently being developed with input from organisations such as the Victorian EPA. It will be implemented by Agsafe using trained auditors.

RESULTS

Fertcare training is now available at three levels:

Level A focuses on handling, transport, storage and spreading. The core module includes a basic understanding of fertiliser and soil ameliorant products including physical identification, understanding labels, storage and handling characteristics, and the main environment and food safety risks. Level A also has three elective modules; spreading, storage and transport.

Level B provides underpinning knowledge of nutrient issues relating to environment and food safety. It comprises basic education in plant nutrition and is designed to enable personnel to improve communication with their customers, and provide warnings and simple advice or to refer customers to Level C trained staff where appropriate. Level B also covers logistics and OHS issues at an awareness level. The major subject areas covered at a medium level of complexity are soils and nutrients, fertilisers, application, environment and food safety, regulation, sampling, logistics, and occupational health and safety issues.

Level C1 provides training that covers a detailed and complex knowledge of environmental issues, fertiliser environmental stewardship review methodology (FESR), food safety issues, sampling, the regulatory framework and label requirements. It also provides awareness of OH&S and stewardship issues in transport, storage, handling and application of fertilisers.

Level C2 is the recognition of prior competency and will include assessment of competency in soil, nutrient and fertiliser knowledge, and systematic development of interpretation and recommendations based on sound science. It will be available from mid 2005.

The Accu-Spread program is available now; premises audits will be implemented from early 2006.

CONCLUSION

Fertcare will provide agricultural industries with an important approach to managing food safety and environmental issues associated with fertiliser use. It has the potential to significantly improve farmer's confidence in advice based on soil and plant testing. It will ensure that the fertiliser industry plays an active role in developing and implementing public policy in these areas.

KEY WORDS

Fertilizer Fertcare Advisor Training

ACKNOWLEDGMENTS

Significant funding for the project has been provided by the Department of the Environment and Heritage, through an Eco-efficiency Agreement, and the Department of Agriculture, Fisheries and Forestry through a National Landcare Program Industry Partnership Agreement.

Paper reviewed by: Bill Porter

Species responses to row spacing, density and nutrition

Bill Bowden, Craig Scanlan, Lisa Sherriff, Bob French and **Reg Lunt**, Department of Agriculture, Western Australia

KEY MESSAGES

- All crops accumulated less biomass at the wider row spacing.
- Better water relations late in the season at wide row spacing gave better harvest indices but grain yields were still lower than at the normal row spacing.
- There were positive biomass and grain yield responses to the addition of fertilisers at almost all density/spacing combinations. Lupins finish slightly better than canola and wheat at wide row spacings.

AIMS AND BACKGROUND

The aim was to better understand the way different crop species respond to wider row spacing.

While a large number of field trials have been conducted on lupin responses to wider row spacing, canola and wheat have received less attention. There have been no comparisons of the response of all three species at the same site in the same year in WA. Understanding the relative responses of the three species is important for predicting how a species will react in a given situation. Moving to wider row spacing also implies a different dynamic in the relative utilisation of soil water and nutrient supplies, which has management implications for the level and placement of those nutrients at different row spacings and seeding rates.

METHODS

The west Moora trial was designed to look at row spacing and seeding rate combinations such that the performance of canola, lupins and wheat could be examined at standard density per unit row length and at the normal density per unit area. A similar trial for lupins only was conducted at Meckering, but measurements were also made on analogous treatments on three (canola lupins and wheat) spacing by time of sowing trials (all trials had the 1st time of sowing (1TOS) on the same day and the 2nd TOS, 21 days later). Trial details are available from the authors or can be found; for the west Moora trial in the NAR 2004 trials report and for the Meckering trials, in the WANTFA 2004 field day booklet pps 17 and 28. Treatment details are self evident in the results tables below.

RESULTS AND DISCUSSION

Together with the data in the tables below, measurements were also made of soil characteristics, establishment, tops biomass, nutrient uptake, root exploration, weed burdens, yield components as well as harvester grain yields and quality. The following comments are subject to statistical analysis.

Table 1. West Moora Row spacing by species results for the "Finish"

Row spacing cm	Seeding rate kg/ha	Fertiliser kg/ha	Canola BY t/ha	Canola GY t/ha	Canola HI %	Lupins BY t/ha	Lupins GY t/ha	Lupins HI %	Wheat BY t/ha	Wheat GY t/ha	Wheat HI %
22	normal	minus	1.8	0.8	48	4.5	1.6	35	3.1	1.8	60
22	3*norm	minus	2.4	0.8	34	5.4	2.3	42	3.9	1.8	46
22	normal	plus	2.5	1.1	44	5.3	2.2	41	3.9	2.2	58
22	3*norm	plus	3.0	1.0	32	6.4	2.6	41	4.4	1.9	44
66	norm/3	minus	1.1	0.6	55	2.0	1.0	50	1.1	0.7	63
66	normal	minus	1.3	0.5	40	3.7	1.5	41	1.6	0.9	59
66	norm/3	plus	1.4	0.7	54	1.8	1.1	60	1.6	0.9	59
66	normal	plus	1.6	0.7	41	4.3	1.8	41	2.1	1.2	57

"Normal" seeding rate set at: canola, 6kg/ha; lupins, 100kg/ha; wheat, 60 kg/ha.
Fertiliser: 120 kg/ha PKSCa to all but "minus" lupins. 50 kgN/ha at 67 DAS for canola and wheat "plus"
BY is tops dry weight on 28 September, GY was the harvested grain yield and HI is the ratio of GY/BY

Table 2. Meckering. Row spacing by species results for the 'Finish' 2004

Row spacing cm	Lupin seed kg/ha	Fertiliser PKSCa kg/ha	Time of sowing	Lupins at shown SR			Canola at 6 kg/ha			Wheat at 60 kg/ha		
				BY t/ha	GY t/ha	HI %	BY t/ha	GY t/ha	HI %	BY t/ha	GY t/ha	HI %
25	**100**	**90**	**Early**	6.7	2.0	29	7.1	1.6	23	8.2	2.1	26
75	**100**	**90**	**Early**	4.6	1.9	41	6.2	1.6	25	5.1	1.3	26
25	**100**	**90**	**Late**	3.9	1.9	49	5.4	1.2	23	5.3	2.9	55
75	**100**	**90**	**Late**	2.4	1.4	58	3.5	0.9	27	2.6	1.7	65
25	**100**	**0**	**Early**	5.3	1.9	36						
75	**100**	**0**	**Early**	3.6	1.6	46						
25	**300**	**0**	**Early**	6.9	1.9	28						
25	**300**	**90**	**Early**	7.3	1.7	23						
75	**33**	**0**	**Early**	2.3	1.5	65						
75	**33**	**90**	**Early**	3.2	1.6	49						

Trials sown on 19 May 2004
Pasture fertiliser at 90 kg/ha PKSCa
BY is tops dry weight on 30 September
GY was the harvested grain yield
HI is the ratio of GY/BY
Wheat plots had significant late weeds

The **wide row spacing plots** yielded less biomass (BY) per unit area than the normal/narrow spaced plots for all species at all treatments (seeding rates, time of sowing and fertiliser additions). Grain yield followed these differences albeit to different extents as reflected in the 'HI' figures. Larger HI values reflect a better 'finish' or conversion of late September biomass to grain yield. This better 'finish' is the traditional reason given for yield responses to wider row spacing.

Increasing seeding rate increases BY but does not always increase GY because the higher, early water use at high density leaves less water to 'finish' the crop.

The addition of fertiliser (at seeding on the lupins and 67 DAS for spread urea on the wheat and canola at west Moora) always increases BY (except for lupins at the low seeding rate and wide spacing at West Moora) and always increased GY except for high seeding rate at Meckering. If anything, the use of fertiliser reduced the positive 'finish' effect of other treatments. The topdressed N at Moora was taken up less efficiently at the wide row spacing, presumably because roots had not penetrated to depth in the inter-row to catch the leaching N. Detailed analysis of the nutrient uptake curves through time will help discriminate species effects.

Late sowing at Meckering markedly improved the 'finish' for wheat and lupins but had little impact on the ability of canola to convert BY to GY.

The **crop species** qualitatively responded in similar ways to spacing, sowing rate, fertiliser and time of sowing. The significance of the interactions will be reported after we have carried out appropriate statistical analyses.

CONCLUSION

The crucial (dollar) question of the magnitude of the grain yield responses, varied markedly. Quantitative responses have always been site, season and management specific. The main task of this and the ensuing project is to predict those quantitative responses for any situation. Data of the sort collected here will be used to structure a predictive model.

KEY WORDS

species, nutrients, fertiliser, row spacing, sowing rate

Paper reviewed by: Ken Flower, WANTFA

Investigations into the influence of row orientation in lupin crops

Jeff Russell, Department of Agriculture and **Angie Roe**, Farm Focus Consultants

KEY MESSAGES

The rise in prominence of tramline farming systems has raised the issue of crop performance as impacted by row orientation.

The results of eleven replicated paddock scale evaluations taken in the 2002 and 2003 seasons are given that compared crop yield and attributes of crop architecture in lupin crops sown in north–south and east–west row orientations.

AIMS

Crop orientation has currently become of interest to growers with the recent developments being generated through 'Tramline' technology systems and Precision Agriculture. Little is known about lupin crop orientation to the sun's transit. Crop architecture as impacted by seeding rate and row spacing may also influence crop performance.

As tramlining means making a decision to sow the paddock in a predetermined orientation over a number of seasons the growers are keen to investigate if there are yield impacts that they may capitalise on.

The concern here is if row orientation influences crop performance as this will have a bearing in the direction of establishing tramlines. This needs consideration when a grower is planning long term farming system changes. If there are yield impacts, then growers may be able to capitalise on them.

METHOD

Simple lupin orientation on farm research activities were conducted using 'bulls eye' level 3 designs (Russell, 2001) or adaptations of these on a number of paddocks in two seasons. Eleven replicated comparisons were conducted on 2 properties in 2002 and 3 properties in 2003. Plant density, pod density and main stem pod height were measured. Grain yield was determined by machine harvesting 3 replicates of each row orientation at 90° to each other.

Genstat V5 was used to perform general ANOVA analysis separately on each of the eleven 'in paddock' comparisons studied.

RESULTS

The two seasons in which this work was conducted were very different to each other (Table 1) in terms of growing season rainfall.

Table 1. Annual rainfall (mm) at Kellerberrin for the three years that the OFR was conducted

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total	GS*
2002													
16.4	0	0	24.2	17.4	33.7	31.8	33.9	6.3	7.4	20.0	14.2	**205.3**	**154.7**
2003													
0	44	28	38	68	40	38	66	23	10	10	8	**377**	**259**
Long term annual rainfall averages†													
11.9	14.5	21	21.6	42.7	55.7	52.6	41.4	25.9	17.8	11.7	13	**329.9**	**257.7**

* GS = growing season rainfall (April-October).
† Average annual rainfall for the last 110 years (BOM, 2004).

Plant densities and attributes measured did not indicate any strong influence of row orientation at the sites studied and suggest uniformity in these. It was only in crop yield that differences were noted.

Eleven replicated paired comparisons of the yield of lupins grown in a NS orientation to those aligned at an EW orientation are shown in Figure 1 below. In five of these comparisons the N-S orientation had superior yields to the E-W orientation but only one set was significantly ($p < 0.05$) greater. Of the six E-W orientations that had greater yields to paired N-S orientations, four of these comparisons showed significantly ($p < 0.05$) greater yields to their corresponding N-S orientation.

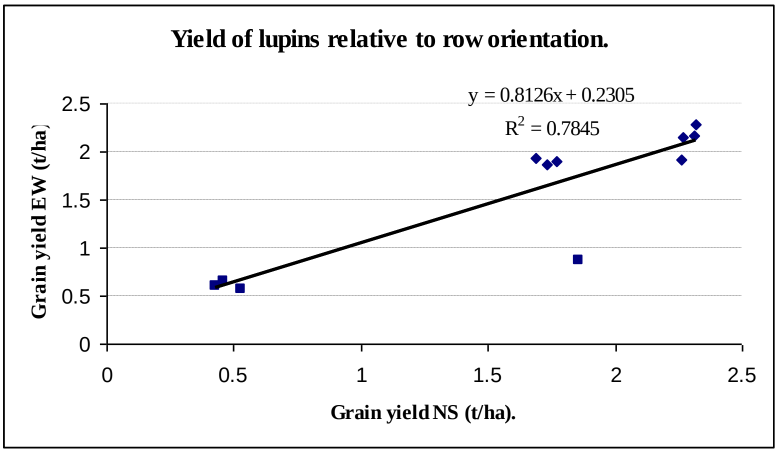


Figure 1. The relationship comparing yields of lupins grown in a NS direction to corresponding lupins grown in an EW direction based on OFR activities in 2002 (♦) and 2003 (■).

CONCLUSION

The orientation results are not definitive for lupins and may very well reflect paddock and site variability. The results seem to be in broad agreement with research conducted by Pathan *et al*. (2005) where no particular orientation has a stronger influence on lupin crop yields (Crop Update 2005, Weed Book). See their paper that details research conducted on a number of crop species at a more intensive scale.

Yield potential does not seem to be an influencing factor as the two seasons in which this was studied were complete opposites yet show similar patterns.

The yield differences measured can be quite large ranging from 170 kg/ha to almost 1.0 t/ha. It may well mean that sowing around the paddock may be still the best alternative with conventional cropping.

In many cases the orientation of tramlines is more likely to be dictated to a greater degree by the soil type and the topography of a paddock. In these cases the practicalities of management will be of greater precedence.

KEY WORDS

row orientation, lupins, tramline farming

ACKNOWLEDGMENTS

The farmers of the Kellerberrin Farm Demo Group. G. Fosbery – Farm Focus Consultants.

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Project No.: 67F Farming Systems Central Wheatbelt

Paper reviewed by: Abul Hashem.

Deriving variable rate management zones for crops

Ian Maling, Silverfox Solutions and **Matthew Adams**, DLI

KEY MESSAGES

The use of Variable Rate Technology is generally profitable where paddocks are of a large size (80 ha or more preferably), there is generally 2-3 tonnes variation in yield across the paddocks (e.g. Adams *et al.* 2000), and the variation that exists in the paddock is consistent across years/seasons. However, the method by which the zones are derived is critical and its integration with best agronomy and fertiliser advice/modelling essential.

AIMS

To examine the variation in biomass/NDVI that exists on some client's paddocks to determine whether this variation is consistent or inconsistent and develop rules of thumb for the use of zones in practical application of variable rate fertiliser application on farm.

METHOD

125 paddocks from Silverfox's database were used to examine the variability in Landsat NDVI imagery provided by the Western Australian Department of Land Information over time (see Table 1). Emphasis on the selection of years was placed on the cereal component of the rotation. The data was classified into six categories: Low, Medium, High performance and either Stable or Unstable through time for each category (L, M, and H). The actual method used is similar to that described in Adams (1999).

Three maps are produced from this analysis: a biomass performance map, which summarises which parts of paddocks outperform other parts of the same paddock; a consistency map, which classifies each pixel as consistent or inconsistent based on the standard deviation of the pixel through time; and a combined performance consistency map, which combines the two previous maps. An example is shown in Figure 1.

RESULTS

Sample analysis

The three maps produced by the modified method of Adams (1999) are shown below for a sample paddock located between Ravensthorpe and Esperance. The years used in the derivation of the maps below were '03, 01, 00, 99.

Performance Consistency Combined

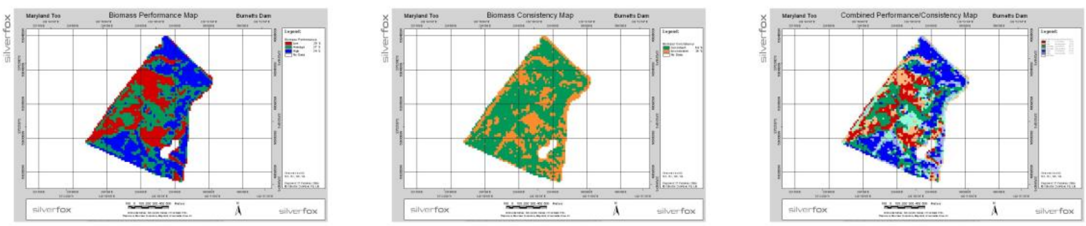

Figure 1. For the Performance and Combined maps, red is low performance; green is average and blue is high performance. In the Consistency map, green is consistent and orange inconsistent. In the Combined map the colours are the same as for the Performance maps except dark colours are consistent and pastel colours are inconsistent areas.

In the sample case above, 65% of the area is consistent in its performance over the 4 years analysed. The distribution of low, medium and high performance zones was 29%, 37%, 34%, respectively.

The table below summarises the analysis of 125 paddocks.

Table 1. Summary statistics of biomass and yield performance and consistency percentages

Statistic	Overall consistency%	High con %	Avg con %	Low con %	High incon %	Avg incon %	Low incon %
Mean	60.70	26.14	26.08	11.29	6.86	15.83	13.77
SD	14.49	7.91	5.76	7.61	3.90	7.88	3.99
Stderr	1.30	0.75	0.55	0.73	0.37	0.75	0.38
Min	32	5	11	2	0	0	3
Max	96	43	41	36	17	40	24
Range	64	38	30	34	17	40	21
N	125	110	110	110	110	110	110

Con = Consistency; Incon = Inconsistency.

With the algorithm and threshold value we use for determining consistency versus inconsistency in performance through time, we found an overall mean consistency rate of 60.7% with a low of 32% and a high of 96% (see Table 1). Mean values of high, average, and low performance were 33%, 42%, and 25%, respectively.

Based on the analysis, experience and experimental results, we have generated the following rules of thumb:

1. Overall consistency must be greater than 56% in total to be considered for VRT and then only if a large proportion of the high performing area is consistent (marginal candidate).
2. Anything in excess of 65% consistent through time is a good candidate.
3. Anything in excess of 75% is a very good candidate.
4. Anything in excess of 85% consistent is an outstanding candidate.

Going to VRT

In example given above, 65% of the area was consistent in its performance over the 4 years analysed, which just gets it into the good category for the application of VRT. However a fair amount of the high performing area is variable and would be included with the average performance areas when zoning up for VRT.

A number of paddock Performance maps may be brought together to get a picture of whole farm performance (Figure 2a). Along with the variability maps they are used to derive VRT zones (Figure 2b). When the VRT zones are combined with soil test and associated modelling the resultant map for DAP application can be produced (Figure 2c).

Farm Performance (2a) Farm VRT (2b) Farm DAP (2c)

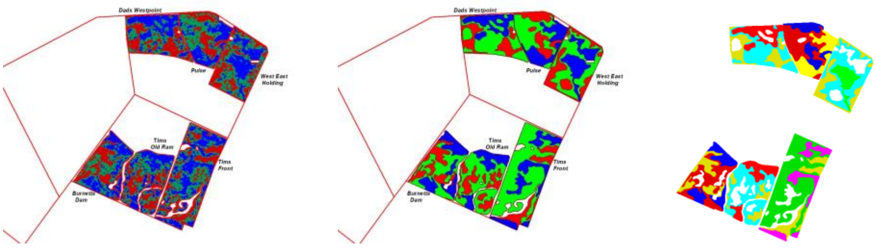

Figure 2. Left is x. Middle is y. Right is z.

The efficacy of any VRT fertiliser map is tested in the year of application by applying all fertiliser rates across each zone then analysing for the benefit or otherwise of the rate used. This approach also provides a dynamic learning model on farm. Current best knowledge is applied and then modified based on the farm results, derived using the farmers equipment and systems. Our experience shows that as long as the zones are tightly defined and consistent in there performance then farmers can get returns in the range of $20-120/ha by using VRT fertiliser rates.

In developing the above approach we have used a combination of a semantically precise deterministic model, tempered by pragmatic empiricism in its application in a manner suggested by Cook *et al*. (1999).

CONCLUSION

There is sufficient variation in paddocks associated with all bar the marginal zones of the wheatbelt to potentially warrant the use of VRT. However to obtain the benefits of using VRT fertiliser rates the zones need to have been derived from temporally stable zones and efficacious fertiliser models. The validity of both are readily tested with VRT equipment and yield monitors on farm and the appropriate analyses of on farm results.

KEY WORDS

variable rate technology, variable rate zones, biomass/NDVI

ACKNOWLEDGEMENTS

Thanks are due to Will Carmody for permission to present data from his property, to DLI for their support and GRDC for its encouragement.

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Paper reviewed by: Bill Bowden

In a world of Precision Agriculture, weigh trailers are not passé

Jeff Russell, Department of Agriculture, Western Australia

KEY MESSAGES

Precision Agriculture allows growers the ability to conduct on farm research (OFR) with greater ease than before. However, reliance on a yield monitor within a harvester for results of final yields may mean that the quality of the data collected could be compromised.

Growers wishing to conduct OFR still need access to weigh trailers to fully realise the benefits to their time and efforts especially if yield differences between the treatments being investigated are small.

BACKGROUND

As part of an OFR activity conducted to investigate cereal crop nutrition, a grower decided to compare final yield results obtained using a calibrated yield monitor on his harvester with that of the weigh trailer built and used by the grower group.

AIM

To validate if yield monitor results are an accurate way to collect results of grower based on farm research.

METHOD

A large scale OFR activity was conducted to compare 9 nutrient treatments and applications to wheat cv. Arrino as a nutritional study by a grower. The treatments were replicated 3 times and harvested by the grower's own machine. Prior to harvesting, the harvester's yield monitor had been calibrated as was the weigh trailer being used to measure the individual plot yields. The harvested plots were measured for length along with the comb front on the harvester to calculate the individual plot areas. All plots were in the order of 0.4 ha in area.

Genstat V5 was used to conduct analysis of variance and linear regression on the results.

RESULTS

The yields obtained by the weigh trailer were consistently greater than those of the yield monitor, on average in the order of about 17% (Table 1).

Table 1. Average treatment yields for the two yield recording systems used in the research

Treatment	Weigh trailer (kg/ha)	Yield monitor (kg/ha)	Average difference (kg/ha)	%
1	1626	1367	259	15.9
2	1588	1305	283	17.8
3	1599	1358	241	15.1
4	1604	1337	267	16.6
5	1568	1337	231	14.7
6	1556	1326	230	14.8
7	1512	1233	279	18.4
8	1634	1318	316	19.3
9	1624	1351	273	16.8
Average	1590	1325	265	16.6
LSD (5%)	60	81		

Statistical analysis of the data for each set of results revealed that significant differences (p value of 0.01, LSD (5%) = 0.06 t/ha) existed between the treatments based on the weigh trailer results, but not on those gained from the yield monitor (p value of 0.088, LSD (5%) = 0.088 t/ha).

Weigh trailer results indicate that treatment 7 yielded significantly less than treatments 1, 2, 3, 4, 8, and 9. Treatment 8 was significantly greater in yield than treatments 5, 6 and 7. The yield monitor results delivered trends in the yields of the different treatments, however, the statistical value of these results was not as confident. Comparative yields of some treatments were quite different in relative terms to that shown by the weigh trailer results.

For all 27 plots the yield monitor consistently measured lower than the weight of grain recorded by the weigh trailer (Figure 1). Regression analysis between the two data sets is not highly correlated having a low r^2 value.

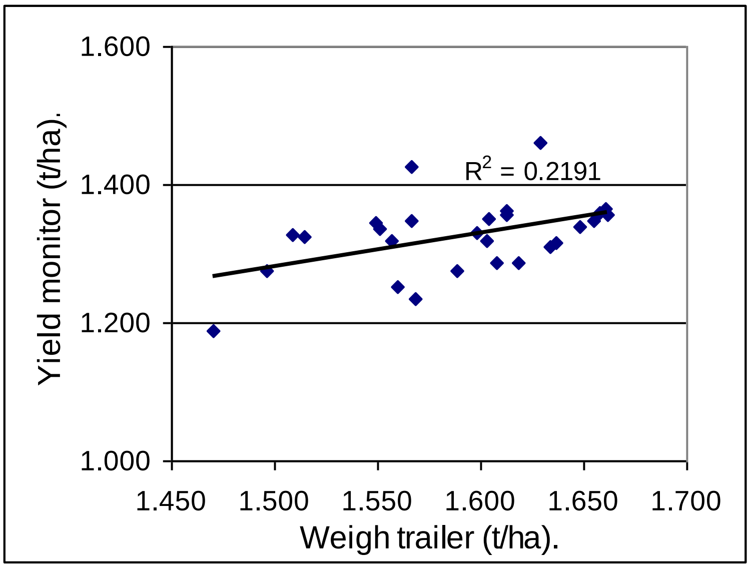

Figure 1. A comparison of the yields of wheat as shown by the yield monitor and to what was recorded using a weigh trailer for all 27 plots harvested.

CONCLUSION

There is the chance that significant differences in yields obtained by weigh trailers may not be captured through the use of a yield monitoring device when doing large scale OFR by growers.

These results indicate that where possible a weigh trailer should be used when determining harvest yields of OFR activities. Reliance on yield monitor data could deliver different results or miss out on quantifying the value of the results obtained. Yield monitors require some form of calibration using an accurate weighing device. This still makes having a weigh trailer a useful requirement.

As with any measuring device whether it be a weigh trailer or yield monitor, it is only as good as its calibration, operation and maintenance allows.

KEY WORDS

Precision Agriculture, weigh trailer, yield monitors

ACKNOWLEDGMENTS

Farmers at Kellerberrin. Farm Focus Consultants.

Project No.: 67F Farming Systems central wheatbelt

Paper reviewed by: Lisa Sherriff

Cover crop management to combat annual ryegrass resistance and improve wheat yields

Jeff Russell, Department of Agriculture and **Angie Roe**, Farm Focus Consultants

KEY MESSAGES

Decisions to brown manure grassy pastures or a cover crop need to take account of seasonal factors and the influence this may have in the subsequent cropping year, in addition to just combating herbicide resistance in weeds.

AIMS

Annual ryegrass (*Lolium rigidum*) is a common weed of cereal farming in the central wheatbelt of Western Australia. Efforts to eradicate this weed have resulted in its selection to varying degrees, of resistance to commonly used 'in crop' herbicides. Cover cropping is one approach to combat ryegrass' selective herbicide resistance by the use of an integrated approach of applying non selective herbicides and the grazing of a sacrificial cover crop or pasture the year before cropping to control seed set in that year.

One grower in the Kellerberrin district has observed ryegrass to become a real problem to control on his property through its developed resistance to in crop Group 'A' herbicides. The grower decided to set up a comparison of two cover crop species and time of spraying with the objective to compare the effects on grain quality and yield in the following wheat crop.

METHOD

Randomised blocks of lupin and volunteer ryegrass pasture were established in 2002 as an on farm research (OFR) activity. These were replicated 8 times. The lupins were grown specifically as a 'crop' to be brown manured. Two times of applying a non selective herbicide (glyphosate) in late winter and spring to control ryegrass seed set were imposed one month apart on the blocks to develop a randomised block of 4 treatments. As it turned out the 2002 season was extremely dry. The site was grazed as part of the paddock over the summer prior to seeding in 2003.

In 2003 the site was sown to wheat. Three rates of nitrogen in the form of urea fertiliser were used at seeding to give a split plot arrangement of each of the cover crop x herbicide timing treatments. Rates of urea applied were 0, 60 at seeding and 120 kg/ha as a split 60 kg/ha at seeding and 60 kg/ha post seeding arrangement. The farmer maintained traffic on all the plots to be the same for this treatment.

Measurements undertaken included weed density ratings and wheat head densities. At harvest, plot yields were measured using a weigh trailer and grain quality from samples from each plot. Statistical analysis was conducted on the data using Genstat and assistance from the Department's Biometrics Branch.

RESULTS

There were no significant effects ($p < 0.05$) on weed density in terms of the previous crop type or early verses late spraying. However, the late spray treatments indicated a higher proportion of ryegrass weeds in crop. Wheat head density (Table 1) was significantly ($p < 0.05$) affected by the time of spray in 2002. The density on the late sprayed plots had on average 22% more heads of wheat per square metre. This translated into 10.5% greater yield but was found not to be significant.

Both yield and protein were significantly improved ($p < 0.05$) with the higher rates of urea applied. Protein also significantly ($p < 0.05$) increased on the lupin treatments compared to the volunteer grass pasture but decreased with the later time of spraying. Screenings fell significantly ($p < 0.05$) with the later time of spraying. Seed weight did not seem to be influenced by any of the treatments applied.

Table 1. Effect of the brown manuring treatments and urea rates on selected measures of the 2003 wheat crop

Cover crop	Spray time	Urea rate (kg/ha)	Head density H/sqm	Grain yield (kg/ha)	Protein (%)	Seed weight (hk/HL)	Screenings (%)
Grass	Early	60+60	157.8	2615	9.22	80.5	4.66
		60	140.4	2488	9.35	79.9	5.08
		0	152.6	2363	8.62	80.7	5.30
Lupin		60+60	173.3	2518	9.82	79.8	5.03
		60	183.3	2275	10.0	79.6	5.31
		0	158.9	2385	9.35	80.2	4.92
Grass	Late	60+60	220.7	2878	9.07	80.2	4.74
		60	191.1	2600	8.87	80.8	4.42
		0	151.1	2423	8.35	81.3	3.77
Lupin		60+60	210.4	2808	9.75	80.3	4.34
		60	202.6	2735	9.57	80.3	4.25
		0	204.4	2748	9.15	80.5	3.60
LSD (5%)			54.3	511	0.44	1.2	1.17

CONCLUSION

Many complex interactions have taken place at this site through the combination of the treatments imposed. There was less of a response to N in wheat head density and yield, where the lupins were sprayed out late than where the grass was sprayed out late. Could this be because the lupins put additional N into the ground in 2002 as a result of being left longer? Did leaving the lupins later increase crop biomass beneath the ground appreciably to influence the results?

Protein was higher where higher rates of N were applied, particularly on the lupin plots of 2002. These results are expected, protein increases as N increases in the form of fertiliser or legume biomass. Protein levels did not reach the ideal target of 10.5%, which indicates that not enough N was applied in 2003.

The results suggest that it is better to spray a crop or pasture out later in the season, than it is to do this early. This is contrary to industry advice in pasture topping/brown manure applications. It may be that the specific seasonal circumstances of 2002, being a very dry year, has contributed to this. This may have impacted on limiting later ryegrass seed set. The later spraying may have allowed the below ground biomass of the lupins to build up. Soil moisture reserves may not have been compromised in this circumstance either, due to the dry season in 2002. The above ground biomass on each treatment was the same at seeding in 2003 due to the grazing management of the paddock. Hence soil biomass and its influence on fertility may be one overriding influence for what was observed.

KEY WORDS

cover cropping, brown manuring, annual ryegrass

ACKNOWLEDGMENTS

K. and E. Leake, farmers at Kellerberrin. G. Fosbery – Farm Focus Consultants.

Project No.: 67F Farming Systems central wheatbelt

Paper reviewed by: Dave Minkey

ARGT home page, the place to find information on annual ryegrass toxicity on the web

Dr George Yan, BART Pty Ltd

KEY MESSAGES

www.argt.com.au is a web site devoted entirely to annual ryegrass toxicity (ARGT). It covers general information on ARGT, its management, as well as its biological control. In addition, it allows farmers to report ARGT outbreaks directly through the web.

The web site www.argt.com.au was developed to promote the awareness of annual ryegrass toxicity, its management and control, and to provide a platform for farmers to report ARGT outbreaks through the web. The service is provided by BART Pty Ltd, the supplier of the twist fungus, a bio-control agent of the causal organisms of ARGT.

There are five major pages in this site. The News page reports the latest development on ARGT, including the latest research results on ARGT control and management, the establishment of twist fungus during the season, and updates on ARGT outbreaks.

The Management page provides technical information on ARGT management, including stock and pasture management, and ARGT control using the twist fungus. Information on how to recognise ARGT symptoms in the field and how to handle animals showing ARGT symptoms is presented in the Symptoms page. The Prevention page concentrates on what measures should be taken to prevent or minimise the risk of ARGT outbreaks.

The Biological control pages focus on the controlling of ARGT using a biological control agent, the twist fungus. There are several linked pages each providing information on how twist fungus interacts with ARGT causal organisms and reduces the risk of ARGT, how to use the twist fungus to limit or prevent ARGT outbreaks, selection of paddocks for treatment, and field application of the biological control agent.

The ARGT outbreak-reporting page allows farmers to report outbreaks through the web. This reporting feature was created in response to a request from the ARGT Action Committee who believed there is currently no suitable avenue for farmers to report outbreaks of ARGT and issues relating to ARGT. The committee is made of representatives from WA Department of Agriculture and Shire representatives from each of the Shires in areas that are prone to ARGT outbreaks. In addition to providing update of the ARGT outbreaks records, the information collected will be used for Government agency decision-making and to formulate recommendations for better management and control of ARGT. Farmers who fill out the form may elect to remain anonymous and under no circumstance will their identity be revealed in public.

The FAQ (frequently asked questions) page provides answers to the most commonly asked questions about ARGT. Farmers will find answers to most of the questions they may have on ARGT management, prevention and control in this area. New questions and answers are added regularly as information becomes available.

The Other sites page provides links to other internet pages or sites where more information on ARGT management can be found. It also provides a quick reference to other mass media such as ABC, which may on occasions report on ARGT related news.

The ARGT web site is relatively easy to navigate. Relevant pages can be accessed through the navigation buttons located either at the top or at the left hand-side of the page. Any feed back on content and future directions for the development of the site should be directed to gyan@argt.com.au.

KEY WORDS

annual ryegrass toxicity, ARGT, twist fungus, biological control

ACKNOWLEDGEMENT

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Paper reviewed by: Dr Ian Riley

Shallow leading tine (SLT) ripper significantly reduces draft force, improves soil tilth and allows even distribution of subsoil ameliorants

Mohammad Hamza, Glen Riethmuller and **Wal Anderson**, Department of Agriculture, Western Australia

KEY MESSAGES

Test of a new generation ripper, which utilises the concept of shallow leading tines provided the following advantages:

- Significantly decreased ripping draft force and thus the cost of ripping.
- Improved soil tilth by significantly decreasing clod size.
- Allowed injection of soil ameliorants at different depths of the subsoil.
- Increased moisture range suitable for ripping the soil thus increasing the time available for the ripping process.
- Decreased wear and tear on ripping components.

BACKGROUND

Soil compaction cannot be eliminated by the application of soil ameliorants and chemicals. Massive structureless soil must be broken down physically by deep ripping. The cost of deep ripping is usually high because it involves a high-energy input. In addition, if the soil is not ripped at the right soil moisture, which occurs in the field in a relatively short time window, large size clods form which restricts the subsequent farm operations and result in poor crop establishment.

Figure 1. Tines are arranged one behind the other in line as shown in the photo. Each tine rips progressively deeper depth as shown in the diagram. This photo shows 4 tines in line in each row. However, the best configuration is a shallow leading tine (SLT) followed in line by only one tine ripping the soil to the required depth.

A new generation ripper (Figure 1) was used which employs the concept of shallow leading tines, SLT, to decrease the cost of ripping and decrease the size of clods usually associated with a classic ripper. The classic ripper opens the soil using one tine inserted into the soil at the required depth, say 0.4 m while the SLT uses one or more tines arranged in-line and each tine rips the soil at progressively deeper depths. For example if we want to rip the soil to 40 cm, the first tine rips the first 10 cm of the soil, the second tine rips the second 10 cm, the third tine rips the third 10 cm, and the fourth tine rips the fourth 10 cm all following each other.

RESULTS

Draft force

A compacted clay soil and a sandy soil at the Merredin Research Station (average soil strength was 2.32 and 2.28 MPa respectively) were ripped at 15.5 and 7.0% soil moisture respectively using a classic and a SLT ripper. The tines were Agrowplow standard tines arranged as the following:

- Classic ripper: One tine at 30 and 37 cm depth for the clay and sandy soil respectively.

- SLT A: Three tines in-line at 10, 20 and 30 cm depth for the clay soil and 17, 27 and 37 cm depth for the sandy soil.
- SLT B: Two tines in-line at 10 and 30 cm depth for the clay soil and 12 and 37 cm depth for the sandy soil.
- SLT C: Two tines in-line at 15 and 30 cm depth for the clay soil and 17 and 37 cm depth for the sandy soil.
- SLT D: Two tines in-line at 20 and 30 cm depth for the clay soil and 22 and 37 cm depth for the sandy soil.
- SLT offset: Two tines at 15 and 30 cm depth for the clay soil and 22 and 27 cm depth for the sandy soil, with the SLT tines not in-line but 22 cm offset from the deeper tines.

Control, no ripping.

Table 1 shows the draft force for each ripping treatment.

Table 1. Draft force in kilonewtons (kn) for ripping clay and sandy compacted soils using classic and shallow leading tine (SLT) rippers and % change

Treatment	Clay soil draft force (kN)	% change	Sandy soil draft force (kN)	% change
Classic	29.3		29.4	
SLT A	29.4	+0.3	29.3	-0.3
SLT B	24.1	-17.8	26.6	-9.5
SLT C	28.4	-3.1	26.3	-10.5
SLT D	30.5	+4.1	28.0	-4.8
SLT offset	32.5	+10.9	31.2	+6.1
LSD (p = 0.05)	4.9			

The clay soil treatment SLT B, two tines in-line at 10 and 30 cm depth and the sandy soil treatment SLT C, two tines in-line at 17 and 37 cm depth showed the minimum force and therefore the least energy required for ripping the soil. The decrease in the draft force using these SLT treatments as compared to the classic treatment were 17.7 and 10.5% respectively.

The decrease in draft force effectively lengthens the time window to capture the right soil moisture to rip the soil, which provides a better chance for farmers to rip their soil, exploiting summer rain. The short time window available for successful ripping is a major shortcoming of the ripping process.

Soil tilth

The size of the clods which are usually associated with deep ripping were much smaller for the SLT ripper as compared to those of the classic ripper.

The soil clod size is very important for crop establishment. Smaller clods are associated with higher crop establishment percentage. Smaller clods also mean a smoother soil surface which leads to more even distribution of moisture after rain.

Ameliorant injection

The SLT ripper was used successfully to inject 2.5 t/ha of lime to 40 cm depth at 44.5 cm tine spacing.

However attaching wings behind the tines could help to mix the lime with the soil. Creating an ameliorated profile free of compaction and chemical constraints for roots to grow through is considered to be very important especially for amelioration of acidic layers which commonly have high levels of toxic aluminium (Bolland *et al.* 2004). The SLT ripper can also inject more than one soil ameliorant into the soil at different soil depths. Immobile nutrients such as phosphorous and sulphur or soil organic matter to improve subsoil structure can also be injected into the subsoil where they can be utilised more efficiently than if they were applied on the top of the soil.

CONCLUSION

The SLT ripper uses significantly less force to rip compacted soils and produces better soil tilth. This means that the ripping work rate (ha/h) can be higher with a SLT ripper and since the soil clods are smaller, the soil moisture window for ripping is wider. The most effective tine configuration was two tines in-line. The first tine is the shallow leading tine, around 1/3 to 1/2 the depth of the second tine. The second tine is the main tine, which rips the soil to the required depth. The SLT ripper can inject and mix with the soil more than one soil ameliorant into the subsoil simultaneously.

More work needs to be carried out on different soils with wings on the tines as the work of Spoor and Godwin (1978) suggests draft reductions of 50% can be achieved.

KEY WORDS

shallow leading tine, ripper, soil compaction, draft force, lime

ACKNOWLEDGEMENTS

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Project number: DAW00002

Paper reviewed by: Chris Gazey

NB: There is an extended version of this paper on the Crop Update 2005 CD.

New annual pasture legumes for Mediterranean farming systems

Angelo Loi, Phil Nichols, Clinton Revell and **David Ferris**, Department of Agriculture, Western Australia

KEY MESSAGES

In the last 10 years, a new generation of pasture legume species has been developed for emerging farming systems of Western Australia. Species such as biserrula (*Biserrula pelecinus*), gland clover (*T. glanduliferum*), French serradella (*Ornithopus sativus*), and yellow serradella (*O. compressus*) have now been commercialized. These species have a broad range of characteristics, which make them productive and persistent under stressful conditions and allowed the development of low-cost seed production systems.

A soon to be released cultivar of eastern star clover (*T. dasyurum*), has also been developed as a useful option controlling of weeds with resistance to selective herbicides.

The new range of pasture legumes provides the opportunity to increase the species diversity of the pasture base. Farmers need to select the most appropriate species based on consideration of soil type, rainfall and farming practice.

RESULTS

*Margurita and Erica hardseeded French serradella (*Ornithopus sativus*)*

French serradella is a highly productive forage legume for light-textured soils. It is very acid tolerant and can exploit deep soils to remain green longer than most other annual pasture legumes. Cadiz, the first cultivar developed, has been widely adopted; however, it does not persist in the long term or in crop rotations due to its almost complete lack of hardseeds. Erica and Margurita are new hardseeded types of French serradella developed from Cadiz. Margurita is very similar in growth habit and appearance to Cadiz and is well suited to forage production. Erica is more prostrate with finer leaves and stems and is considered more grazing tolerant. Their hardseed attributes ensure good germination at the break of season, while also enabling persistence through crop rotations. As with Cadiz, seed of both Erica and Margurita is easily harvested using a conventional header. However in contrast to Cadiz, seed needs to be extracted from pods and scarified for high germination levels. Good seed quantities of both cultivars will be available in 2005.

*Mauro Biserrula (*Biserrula pelecinus*)*

Biserrula is well adapted to a wide range of soil types and pH levels, but does not tolerate waterlogging. It is a very productive species with a deep root system, enabling it to provide a longer period of green feed for grazing animals. Biserrula is extremely hard seeded, making it ideal for ley farming systems. Furthermore, its seed does not soften until mid-late autumn, allowing it to escape false breaks. Mauro is two weeks later flowering than the original cultivar, Casbah and is less hardseeded, resulting in higher second year regeneration densities. It is suited to mixed farming and permanent pastures in 450-700 mm rainfall areas. Good seed quantities will be available in 2005. Farmer observations and recent experimental work have shown that over a short period of time in spring, sheep begin to avoid biserrula and preferentially graze the non-legume components of the pasture, rapidly leading to legume dominance. This is highly beneficial for the management of herbicide resistant weeds such as annual ryegrass and is likely to reduce the use of herbicides in cropping systems. A few instances of photosensitisation, however, have been reported on sheep grazing Casbah biserrula-dominant pastures and the Department of Agriculture is investigating their possible connection.

*Urana, Izmir and Coolamon subterranean clovers (*Trifolium subterraneum*)*

Izmir is a hardseed replacement for Nungarin with greater persistence in cropping rotations. It is suited to areas receiving ≤ 375 mm annual rainfall. Over all trial measurements, Izmir produced 10% more winter herbage and 7% more spring herbage than Nungarin. This advantage was greater following seasons where trial sites were either cropped or sprayed out to prevent seed set. Urana is suited to areas with annual rainfall of 400-525 mm. It has a flowering time later than Dalkeith but earlier than York and Seaton Park and is well suited to mixtures with these cultivars. Urana has very vigorous growth and its high hardseededness should also enable it to persist better in cropping

rotations than current cultivars. Coolamon is a replacement for Junee suited to both mixed farming and permanent pastures in areas with 500-700 mm annual rainfall. Coolamon is more resistant to Race 1 and Race 2 of clover scorch than Junee, which is susceptible to the newer race. Across all trials Coolamon had 11% better regeneration density and produced 10% more herbage in winter, 14% more herbage in spring and 4% more seed than Junee. Good seed quantities of Urana and limited quantities of Coolamon will be available in 2005, while limited seed of Izmir will be available in 2006.

*Scimitar and Cavalier burr medics (*Medicago polymorpha*)*

Burr medics are adapted to mildly acid loam and clay soils. Their hardseededness makes them well suited to ley farming systems. They are also tolerant of moderate salinity, in the absence of prolonged waterlogging. Scimitar and Cavalier are more productive and softer-seeded than the original cultivars, Santiago, Circle Valley and Serena, giving them greater second year regeneration. Scimitar is an alternative to Santiago, suited to ≥ 325 mm annual rainfall areas, while Cavalier is a replacement for Circle Valley, suited to ≥ 425 mm annual rainfall areas. Both have low levels of blue-green aphid resistance, but are susceptible to cowpea aphids. Seed of both cultivars should be available in 2005.

GCN39 Eastern star clover (Trifolium dasyurum)

Eastern star clover GCN39 is a new species to Australian agriculture. It has high levels of dry matter and seed production and can be harvested with conventional harvesters. GCN39 is an early-mid maturing variety that is planned for release in 2006. It flowers approximately 100 days after emergence in Perth and is suitable for use on acid and alkaline fine textured soils in low to medium rainfall areas (350-500 mm). Seeds weigh approximately 4 mg each. GCN39 germinates very late in the season compared to traditional pasture legumes and weeds. This characteristic is related to its peculiar and unique pattern of delayed seed softening combined with delayed imbibition. The delayed germination in GCN39 offers farmers a new opportunity to control weeds during the pasture phase. Non-selective herbicides or intensive grazing can be used after the opening of the season for 4-6 weeks before GCN39 germinates, to obtain 99% weed control. Table 1, summarises an experiment conducted at Bakers Hill, Western Australia, in 2003/4. In 2003 a grazing trial was sown with subterranean clover cv. Dalkeith and Eastern star clover GCN39. In 2004 the plots were left to regenerate and a strategic knock down herbicide (glyphosate 1.5 L/ha) was applied on May 27 (5 weeks after the break). Weed densities were substantially reduced and all subterranean clover seedlings were killed. However, GCN39 regenerated densely and was highly productive, despite its late germination.

Table 1. Plant densities (plants/m^2) of eastern star clover (ESC), subterranean clover (Sub) and weeds in unsprayed and sprayed treatments (5 weeks after glyphosate application)

Plots	ESC	Sub	Grasses	Capeweed
	Unsprayed plots			
Eastern star clover	722	4220	6325	1224
Subterranean clover	10	5160	5295	418
	Sprayed plots			
Eastern star clover	475	58	165	0
Subterranean clover		61	145	4

CONCLUSION

These new pasture legumes have been selected with attributes leading to increased pasture productivity and persistence. By increasing legume dominance of the pasture, feeding value of the pasture is increased, with consequent benefits for animal production. Crops in rotation also benefit through increased nitrogen fixation and the availability of new alternative weed control options. Mixtures of cultivars and species can be used to provide a buffer against different seasonal effects and soil types within the paddock.

KEY WORDS

pasture legumes, hard seed, farming systems, weed control

ACKNOWLEDGMENTS

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Paper reviewed by: Brad Nutt

How sustainable are phase rotations with lucerne?

Phil Ward, CSIRO Plant Industry

KEY MESSAGES

Annual crops and pastures leak water and contribute to dryland salinity, but lucerne can help to prevent water leakage.

A simple model is available which can calculate the impact of a phase rotation on average long-term leakage in south-western Australia. This will assist landholders and advisors to determine a phase rotation suitable for environmental sustainability, and then make informed decisions as to whether such a rotation is worth pursuing.

AIMS

In Western Australia, lucerne and other perennials have been proposed as a possible means to reduce groundwater recharge, particularly if grown in a phase rotation with annual crops and pastures. However, few guidelines are available with regard to appropriate lengths of the annual and perennial phases for different regions of the Western Australian wheatbelt. In this paper I will introduce a simple model (LBuM – the LEakage/BUffer Model) which allows landholders and their advisors to determine suitable phase rotation lengths for any of 25 locations and 5 major soil types in the wheatbelt.

METHOD

LeBuM – the concept

Leakage beyond the root zone and potentially into the groundwater mostly occurs when the soil is saturated, which is most common during winter. Therefore, if we can dry the soil over summer to make more space at the start of winter in which to store water, the soil is less likely to fill, and leakage to groundwater is reduced. The deep roots and summer activity of lucerne and other perennials operate in this way (Figure 1). In this example, lucerne roots gradually grow deeper during the 3-year lucerne phase, drying the soil to a greater depth (and creating a larger buffer) each year. When lucerne is removed and cropping commences, water that could otherwise have leaked into the groundwater is stored in the buffer, and therefore is retained in the soil. If we know how much extra water storage space lucerne gives us, and if we have a long sequence of yearly leakage quantities under annual crops, we can calculate the long-term impact of a perennial phase on average yearly leakage.

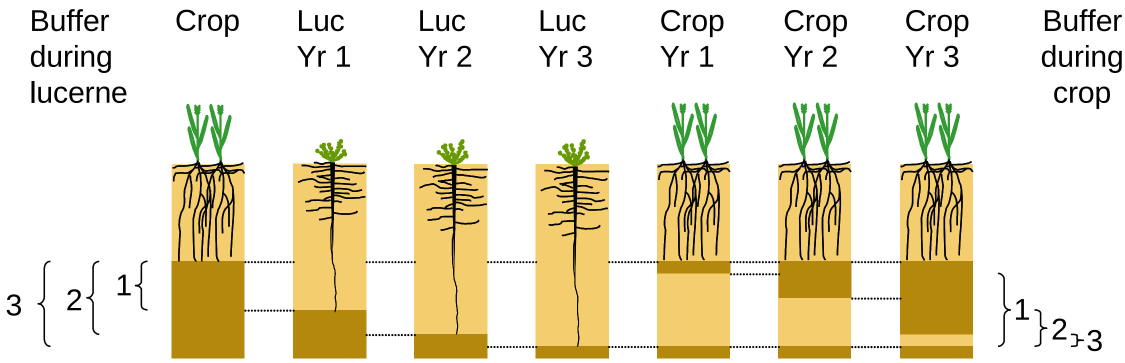

Figure 1. A conceptual diagram of a phase rotation.

The biggest assumption of LeBuM is that water fills the buffer evenly from the top, and does not flow rapidly through large pores in the buffer. If rapid flow through the buffer does occur, then water will start to leak out of the buffer before it is filled, reducing its effectiveness. This is known to occur in some soils, and can be particularly common in cracking clays. In trials in Western Australia, the buffer created by lucerne was always filled within a few years, and so this assumption is reasonable for most Western Australian soils and climatic conditions.

LeBuM operation

LeBuM is an MS Excel spreadsheet that comes with 125 sequences (25 locations by 5 soil types) of 100 years (1901-2000) of modelled annual leakage data. The user just has to specify the location and soil type of interest. The user can then change factors such as the length of the cropping or perennial phases (in years), and the amount of extra water the perennial uses relative to the water use by annual crops. This allows the user to determine the impact of the perennial phase on long-term average leakage compared to the long-term average leakage under annuals (Figure 2). LeBuM also calculates the maximum, minimum and average number of years that the buffer created by the perennial will last.

Input data	
Years of perennial (0-5)	3
Max buffer developed by perennial (mm)	100
% of buffer developed in year 1	50
% of buffer developed in year 2	80
% of buffer developed in year 3	100
Years of crop (0-20, v for variable until buffer is filled)	3
Any extra water use by crops (mm)	0

Run for specific buffer size

Vary buffer size 0-500 mm
See results in "Summary"

LeBuM

Output Data					
Location	Jerramungup	Jerramungup	Jerramungup	Jerramungup	Jerramungup
Soil Type	Acid loamy sand	Duplex	Gutless sand	Loamy sand	Water-logging duplex
Average Leakage under annuals (mm)	31.3	9.9	54.1	8.8	19.0
Average leakage under new rotation (mm)	9.4	1.1	25.5	0.6	2.9
Average years of crop before buffer is filled	4.3	11.0	2.7	15.4	6.5
Minimum years of crop before buffer is filled	1.0	1.0	1.0	1.0	2.0
Maximum years of crop before buffer is filled	11.0	27.0	8.0	39.0	14.0

Figure 2. The LeBuM Layout, which shows all the parameters and calculated values on one screen.

RESULTS

In the example above (Figure 2), a phase rotation of 3 years of perennial/3 years crop was modelled for 5 soil types in the Jerramungup region. The perennial was assumed to create a buffer of 50 mm after the first year, 80 mm after the second year, and 100 mm after the third year, which is broadly in line with measurements of lucerne water use made at a trial near Katanning. The phase rotation decreased leakage from 31 mm to 9 mm in the acid loamy sand, and a buffer of 100 mm lasted on average 4.3 years, but could last anywhere between 1 and 11 years depending on the run of seasons. For the Jerramungup region, lucerne was most effective on the duplex, waterlogging duplex and loamy sand soils, decreasing long-term average leakage by 85-95%. Leakage reduction of this magnitude in valley floors could be sufficient to prevent the onset of dryland salinity, or at least delay it by as much as several decades.

CONCLUSION

A simple model (LeBuM) is available which can calculate the impact of a phase rotation on average long-term leakage in south-western Australia. The main assumption is that preferential water flow through the buffer does not occur, and this is reasonable for most Western Australian soils. LeBuM can assist landholders and advisors to determine a phase rotation suitable for environmental sustainability, and then make informed decisions as to whether such a rotation is worth pursuing.

KEY WORDS

LeBuM, salinity, model

Paper reviewed by: Perry Dolling and David Hall

Management practicalities of summer cropping

Andrea Hills and **Sally-Anne Penny**, Department of Agriculture, Western Australia

KEY MESSAGES

- A winter fallow or failed winter crop provides the best opportunity to grow a summer crop.
- Soil moisture is more important than soil temperature for successful establishment.
- No advantage has been seen in using wide skip row spacing.

BACKGROUND

Summer crops are seen by a growing number of farmers as an option to produce out of season grain and forage, manage herbicide resistance by reducing the weed seed bank with winter applications of non-selective herbicides, lower the risk of winter waterlogging and diversify their farming system. Summer cropping management techniques used elsewhere in Australia are not always applicable to the south coast region of Western Australia.

AIM

The aim of this paper is to outline the practical aspects of producing forage and grain summer crops in the south coast region of Western Australia.

METHOD: 2001-2004

The risk analysis was undertaken by using Agricultural Production Systems sIMulator (APSIM) to provide best bet options to maximise summer and winter crop productivity. APSIM was configured for south coast soils and used 46 years of local historic weather data to predict biomass and yields. From 2001-2004, research sites and farmer demonstration sites were established extensively in the south coast region to provide yield and productivity data, which also verify's the model simulations.

RESULTS

Rotation

● Actual and APSIM modelled data have found the most reliable system of growing a summer crop is after winter fallowing with this being planned or as an opportunity such as a failed winter crop. Summer crops can also be sown after hay cutting, swathing of crops, harvest of crops, or green manuring of crops.

Sowing summer grain crops after the harvest of a winter crop can decrease productivity. This is because the stored soil water has been used by the previous crop and the later sowing pushes flowering and grain filling of the summer crop into late summer, which are the hottest and most variable months for rainfall.

APSIM simulations have found that growing a summer crop after fallowing in an area with a September to March average rainfall of 227 mm grain can be produced every one in three or four years but if it is after a winter crop then grain is produced every one in five years with an average yield of only 10-20 per cent of the biomass (refer to Risk analysis of summer cropping paper).

● Summer crop harvest may conflict with early winter crop seeding when summer species are sown late or mature late. South coast farmers use crop desiccants, swath, plant earlier, or use shorter maturing varieties to overcome this issue.

● Summer crops may become a weed in the following winter crop. A broadleaf summer crop such as sunflowers will be difficult to control in a following broadleaf winter crop due to its ability to reshoot/germinate in colder temperatures and limited chemical options.

Agronomy

● Summer crops require slightly different agronomy to winter crops to reduce the risk of failure and ensure good crop growth. For example, many summer crops have minimum soil temperature requirements at sowing. On the south coast region when soil temperature is ideal, moisture is compromised. It is preferable to sow early and pursue moisture rather than wait and miss a good soil moisture opportunity. Trials at EDRS have shown that establishment is unaffected but initial plant vigour is slowed when planted a lower soil temperature (Table 1).

Table 1. Plant establishment of BMR sorghum, Nutrifeed and Shirohie millet over three different sowing dates and soil temperature (2004, Esperance Downs RS)*

2003/04	Plant establishment (plants/m^2) for each TOS		
Summer crop	**15 Oct.**	**4 Nov.**	**24 Nov.**
BMR sorghum	16.8 a	19.7 a	21.1 a
Nutrifeed millet	25.3 a	36.3 a	24 a
Shirohie millet	84.8 a	85.8 a	91.9 a
Average soil temperature at sowing (°C)	**13.6**	**15.4**	**16.1**

* Numbers within rows followed by the same letter are not significantly (P > 0.05) different.

● Some crops such as sunflowers are best sown with a precision seeder as results with other machines are variable. Sunflowers need to be evenly spread along the row otherwise production penalties will result particularly with clumping of plants or plants grown singularly.

● Fertiliser needs to be deep banded or applied at a time before seeding to wash into the soil.

● Wider row spacing are necessary for some summer crop species but the wide skip row configurations used in the Eastern States showed no advantage in WA trials where dry matter and grain yields were lower than on narrower spacing (Table 2). Very high rates of production can be achieved with row spacings of 0.5 m for sorghum and Nutrifeed – in 2003-04 the peak biomass for these two forages was 5.4 and 6.4 t/ha and individual plots of Nutrifeed reached 8 t/ha.

Table 2. Dry matter production (t/ha) at two row spacings in Scaddan (14 April) and Esperance Downs Research Station (26 March) in 2002-03

		Row spacing (cm)	
Trial site	**Forage**	**50 cm**	**100 cm**
Scaddan (mallee)	Nutrifeed	3.7	2.6
	Pacific BMR	4.5	2.2
Esperance Downs RS (sandplain)	Nutrifeed	-	3.0
	Pacific BMR	0.83	0.45

CONCLUSION

Unsuitable rotations will result in production penalties for the summer crop and logistical problems for the following winter crop.

The best opportunities arise from sowing into a fallow/failed winter crop than straight after the harvest of a winter crop.

Management realities require growers to chase moisture rather than adhere solely to exact soil temperatures at sowing, and narrow row spacing produces better DM and yield results than wide skip row spacing.

ACKNOWLEDGEMENTS

We would like to thank David Hall, Colin Boyd, Noel Rennie, Penny Malone, Ken and Audrey de Grussa (Neridup), Ron and Kerry Longbottom (Scaddan) and Dr Michael Robertson and Don Gaydon CSIRO, Brisbane Queensland.

GRDC Project No.: DAW 722

Paper reviewed by: Matt Ryan

Rainfall zone determines the effect of summer crops on winter yields

Andrea Hills, Sally-Anne Penny and **David Hall**, Department of Agriculture, Western Australia

KEY MESSAGE

- Low rainfall zones will suffer yield penalties of 30–40% in winter crops following summer crops.
- In the medium rainfall zone, winter crops did not have a yield penalty.
- Water use trends in the medium rainfall areas suggest that some summer crops use stored soil water which could result in a yield benefit (where waterlogging occurs) or penalty (in a drought season).

AIM

Farmer observations in the medium–high rainfall zones were that summer crops dried the soil profile so that the onset of winter waterlogging was delayed, benefiting the winter crop. However, in lower rainfall environments, summer rainfall is often conserved to maximise winter crop yields, and the penalty from growing a summer crop is unknown.

The aim of this paper is to outline how summer crops affect the growth of the following winter crop.

METHOD

There were three trial sites (2001-2004), Table 1 shows their characteristics. Summer species had dry matter, grain yield, rainfall, water use and end of season rooting depth measured. In the following autumn, winter crops were sown over the trial plots using farmer machinery and monitored for dry matter, grain production and water use (at Esperance Downs Research Station only).

Table 1. Trial site details

Site particular	Mt Madden	Neridup	Esperance Downs RS
Rainfall zone	low (< 325 mm aar)	medium (325-450 mm aar)	medium (350-450 mm aar)
Summer crop trial type	large scale	small plot	small plot
Winter crop	wheat (Machete)	lupins	lupins (Tanjil)
Soil type	shallow sandy loam over alkaline clay	sand over clay at 1.4 m	sand over clay at 0.8 m
Water use technique	gravimetric	gravimetric	neutron probe

The Agricultural Production Systems sIMulator (APSIM) was configured for south coast soils and used 46 years of local historic weather data to predict the grain yields of winter crops that were grown following either a summer fallow or sorghum.

RESULTS

At Neridup and EDRS (Table 2), summer crops did not reduce the grain yield of the following lupin crop, although there was a downwards trend for some. At Neridup, the lupins grown on the millet and sunflower plots had higher grain yields than those on the traditional summer fallow. As waterlogging did not occur on any plots at the site, the reason for this yield increase is unknown.

Figure 1 shows how lupin water use at EDRS declines as summer water use increases - in a normal winter season, rainfall in the medium rainfall zone is sufficient to overcome lower levels of stored soil water, but in a drought year yield penalties from water stress could occur. Conversely, in situations

where winter crops have an excess of water (waterlogging), summer crop water use could create a buffer by drying the soil profile, allowing more winter rain to fall before waterlogging occurred, resulting in higher yields.

The APSIM model predicts a 200-400 kg/ha yield penalty in cereals following a summer crop. In high rainfall zones, this makes up a smaller proportion of total potential yield than in the low rainfall areas.

At Mt Madden (Table 2), the wheat yield was reduced for all treatments, ranging from 57–79 per cent of the summer fallow. This is a greater proportion than the penalty predicted by APSIM, which is likely to be due to the extremely dry season (especially spring) in 2002.

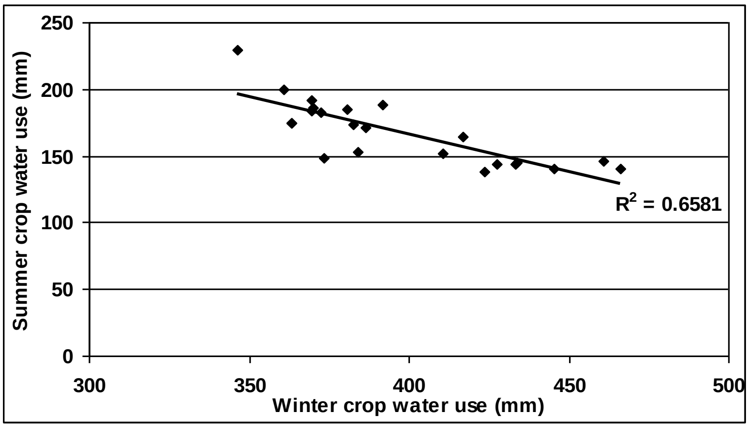

Figure 1. Water use in a winter lupin crop following various summer crops at EDRS in 2003-04.

Table 2. Summer crop effect on the following winter crop grain yield, as a percentage of the traditional summer fallow, at three sites and two seasons

		Mt Madden 2002 (wheat)	Neridup 2002 (lupins)	EDRS 2004 (lupins)
Summer crop	**Variety**	**Winter yield % control**	**Winter yield % control**	**Winter yield % control**
Fallow		100 a	100 a	100 a
Forage sorghum	Bettagraze	59 b	98 a	
	BMR		97 a	90 a
Grain sorghum	Western Red	60 b	86 a	
	Legend	61 b		
Corn	3335	57 b		
	3527	79 ab		
Sunflower	Polysun	64 b		
	Advantage	60 b		
	Sunbird 7		105 b	
Forage millet	Nutrifeed		115 b	71 a
Japanese millet	Shirohie		136 b	89 a
Proso millet	White French	60 b	126 b	91 a
Foxtail	Panorama			65 a
Pearl millet	NPM 3			65 a
Oats	Carrolup			89 a

Numbers in a column followed by the same letter are not significantly (P > 0.05) different.

CONCLUSION

Summer crops are likely to cause yield penalties of up to 30–40 per cent in cereals in the low rainfall areas where winter crops rely on stored soil moisture to reach maximum yields.

In the medium rainfall areas, yield benefits in lupins were seen from growing summer millet species although the reason for this was not identified. Neither site became waterlogged, so farmer observations of summer crops delaying waterlogging in winter crops could not be assessed, although water use trends in one trial suggest this could occur. However, as summer crops did use stored soil water, yield penalties in winter crops in the medium rainfall could occur if a spring drought caused greater reliance on depleted stores of soil water.

ACKNOWLEDGEMENTS

We would like to thank Colin Boyd, Noel Rennie, Penny Malone, Ken and Audrey de Grussa (Neridup), Owen and Terri Brownley (Mt Madden), Vanessa Johnson, Michael Robertson (CSIRO Brisbane) and Don Gaydon (CSIRO Brisbane).

GRDC Project No.: DAW 722

Paper reviewed by: Ben Curtis

Summer crops and water use

Andrea Hills, Sally-Anne Penny and **David Hall,** Department of Agriculture, Western Australia and **Michael Robertson** and **Don Gaydon**, CSIRO Brisbane

KEY MESSAGES

- Summer crops do not use as much summer soil water as established lucerne.
- October sown summer crops use 0-30 mm more stored soil water than the traditional summer fallow, reducing leakage below the root zone by 2–27 mm.

AIM

Summer crops were proposed as a way of using out of season rainfall and creating a buffer in the soil profile to reduce leakage below the root zone in winter crops.

The aim of this paper is to outline the water use of summer crops relative to annual winter crops and lucerne and the implications of this for leakage that contributes to groundwater recharge.

METHOD

Measurements were made between 2002-2004 at four trial sites at two locations in the Esperance region (Table 1). Summer crop species were measured for dry matter, grain yield, water use and end of season rooting depth.

Table 1. Trial site details

Trial location	Scaddan	Gibson		
Site name	Tidow	EDRS E1	EDRS N13	EDRS W4
Long term Sept.-March rainfall (mm)	181	227		
Actual Sept.-March rainfall (mm)	222 (2001-02); 177 (2002-03)	312 (2003-04)		253 (2002-03)
Soil type	shallow sandy loam over alkaline clay	sand over clay at 0.8 m	sand over gravel at 0.3 m	sand over clay at 0.5 m
Soil water measurement technique	neutron probe	neutron probe	gravimetric	gravimetric

Modelling using the Agricultural Production Systems sIMulator (APSIM) was conducted for three south coast soil types (deep sand, shallow duplex and medium duplex) and used 42 years of local historic weather data to predict sorghum and winter crop production and soil water leakage below 150 cm. APSIM used six scenarios of winter wheat, annual pasture or failed winter crop followed by summer fallow or sorghum at three locations; Salmon Gums, Scaddan and Myrup.

RESULTS

A weedy fallow can use the same amount of water as a summer crop while a clean fallow will use from 7–45 mm less than a summer crop (Table 2).

Table 2. Measured water use and rooting depths for summer crops in three trials over two years

Site	EDRS (W4)		EDRS (E1)	
Sowing date	**24/9/02-Sunflowers, 22/10/02 – other spp.**		**31/10/03**	
Species	**Rooting depth cm**	**Water use mm**	**Rooting depth cm**	**Water use mm**
Fallow		204	107 (fleabane)	163
Nutrifeed	72	239	107	184
Pearl millet 3	100	237	77	168
French white millet	77	234	83	162
BMR sorghum			90	170
Bettagraze	70			
Sweet Jumbo		232		
Sunflower XF516	65	249		
Sunflower Hysun 38	85	211		

APSIM modelling (Table 3) showed the average annual leakage below 150 mm can decrease if a sorghum crop is used in the rotation, when compared with a weed free fallow. Leakage is decreased most (by up to 27 mm) where the sorghum follows a failed winter crop and least when it follows a wheat crop. These results are consistent with summer crop trials.

Table 3. APSIM crop modelling results for total average annual drainage (mm) at three locations and six possible rotations

APSIM scenario	Total average annual drainage (mm)		
	Salmon Gums	Scaddan	Myrup
Wheat-fallow	3	24	111
Wheat-sorghum	1	20	104
Pasture-fallow-wheat	7	46	146
Pasture-sorghum-wheat	3	30	142
Failed winter crop-summer fallow	38	61	152
Failed winter crop-sorghum	15	34	139

The water use of lucerne in its first year of establishment was not significantly greater than the sorghum or summer fallow (Table 4). However, at the same site in the following year, the extraction depth of the lucerne increased significantly and its water use was greater than the fallow or sorghum.

Table 4. Water use of perennial, annual and summer crops at Scaddan across two seasons

		2001-02		2002-03	
Treatment	Row spacing (m)	Water use mm	Extraction depth m	Water use mm	Extraction depth m
Cereal/fallow	-	179	103 a	132	93 b
Lucerne	0.22	188	97 a	186	170 a
Sorghum	0.5	165	107 a	-	
Sorghum	1	176	97 a	142	80 b
Sorghum	1 m single skip	183	103 a	-	

Numbers in a column followed by the same letter are not significantly (P > 0.05) different.

CONCLUSIONS

Actual and modelled summer crops were found to increase evapotranspiration and reduce soil water storage by approximately 10-30 mm when compared to a weed-free summer fallow. This resulted in a 2-27 mm reduction in leakage beyond the root zone. In relatively weedy summer fallows, particularly where fleabane and wireweed were present, the differences in soil water storage between summer crops and summer fallow are minimal.

The water use, root depth and ability to dry profiles prior to the autumn break was shown to be significantly less for summer crops compared to established lucerne which reaches maximum rooting depth in it’s second year.

The best scenario to reduce drainage is through deep rooted perennials as opposed to summer crops.

ACKNOWLEDGEMENTS

We would like to thank Colin Boyd, Noel Rennie, Geoff and Leanne Tidow, Vanessa Johnson and Penny Malone.

GRDC Project No.: DAW 722

Paper reviewed by: Dr Rob Sudmeyer

Risk analysis of sorghum cropping

Andrea Hills and **Sally-Anne Penny**, Department of Agriculture, Western Australia and **Dr Michael Robertson** and **Don Gaydon**, CSIRO Brisbane

KEY MESSAGES

- Forages are more reliable in productivity compared to grain crops over the long-term.
- Productivity is affected by sowing opportunities and rotation

BACKGROUND

Summer crops are seen by a growing number of farmers as an option to produce out of season grain and forage, manage herbicide resistance by reducing the weed seed bank with winter applications of non-selective herbicides, lower the risk of winter waterlogging and diversify their farming system. The effect of rainfall zone and seasonal variation on summer crop production is not widely known.

AIM

Aim of this paper is to outline the risk analysis of producing forage and grain sorghum crops on the south coast region of Western Australia.

METHOD: 2001-2004

The risk analysis was undertaken by using Agricultural Production Systems sIMulator (APSIM) to provide best bet options to maximise sorghum and winter crop productivity and to minimise deep drainage. APSIM was configured for south coast soils and used 46 years of local historic weather data to predict biomass and yields for three locations; Myrup (high rainfall, average Sept.-March 227 mm), Scaddan (medium rainfall, average Sept.-March 181 mm), and Salmon Gums (low rainfall, average Sept.-March 168 mm).

From 2001-2004, research sites and farmer demonstration sites were established extensively in the south coast region to provide yield and productivity data to verify model simulations.

RESULTS

Grains versus forages risk analysis

Given the variability in summer rainfall, sorghum grain crops can be the riskiest to grow compared to summer forages. This is because once forages are established, their profitability does not hinge on timely rainfall events, although dry matter production (and profitability) will increase greatly with frequent rainfall.

Research and demonstration sites results from 2001 to 2003/04 matched the model simulations for those years.

From this, actual and modelled (APSIM) summer crops have found that growing sorghum in a pasture–sorghum-wheat rotation at Myrup and Scaddan that biomass can be achieved every season. Average biomass yields for Scaddan, and Myrup were 3, and 4 t/ha respectively.

APSIM predicted a breakeven grain yield is only produced 1 in 5 years at Scaddan and every 1 in 3-4 years at Myrup (breakeven grain yields are based on sorghum production costs of $150/ha and a gross income of $175/ha) equating to a grain yield of 850 kg/ha (Figure 1 and 2).

When growing sorghum in an opportunity system (that is sown after a winter crop), crops produced biomass in 1 in 3 seasons at Salmon Gums and Scaddan, and 1 in 2 at Myrup. Grain was produced in 1 in 5 season's at all three locations with an average yield of only 10-20 per cent of the biomass.

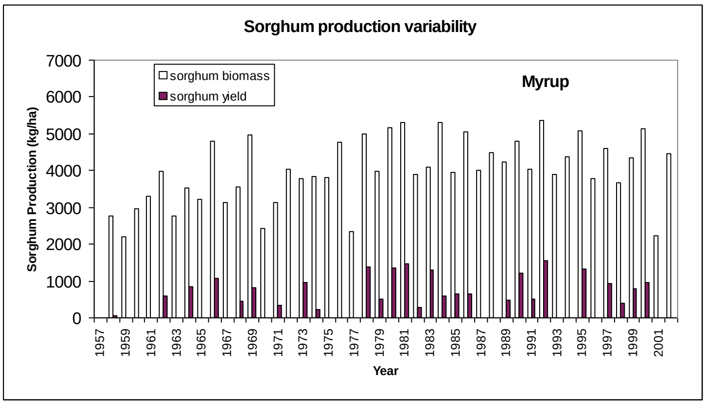

Figure 1. **APSIM simulated sorghum production comparing biomass to grain yield from 1957 to 2003 at Myrup in a pasture-sorghum-wheat rotation.**

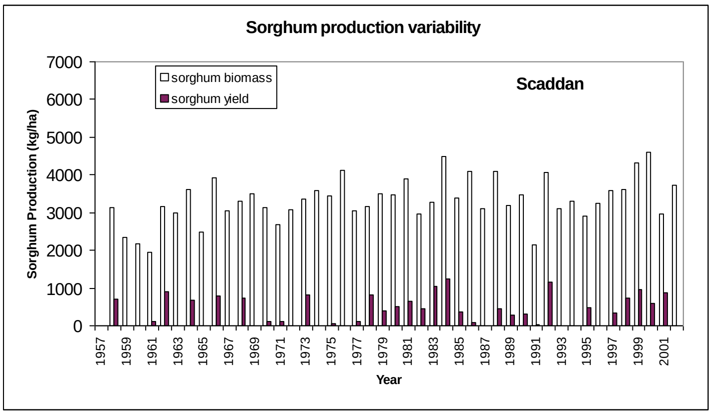

Figure 2. **APSIM simulated sorghum production comparing biomass to grain yield from 1957 to 2003 at Scaddan in a pasture-sorghum-wheat rotation.**

Experimental and demonstration sites from 2001-2004 showed production levels of grain and biomass varied greatly regardless of previous crop rotation. Biomass yields ranged from 1.5 t/ha to 3.7 t/ha during the drier summer rainfall seasons of 2001/02 and 2002/03. In the wetter summer rainfall in 2003/04 yields ranged from 2.6 t/ha to 5.4 t/ha.

Grain sorghum yields ranged from< 0.1 t/ha (failure) to 1 t/ha.

CONCLUSION

Sorghum grain crops are a relatively high risk cropping option compared to a summer forage crop, with this risk increasing as summer rainfall decreases. There is a better opportunity for summer crop production from sowing into a fallow/failed winter crop situation than following a winter crop.

Grain yields are highly variable reflecting both the total seasonal rainfall and the distribution of rainfall over the summer period.

ACKNOWLEDGEMENTS

We would like to thank David Hall, Esperance Downs Research Station staff (Colin Boyd, Noel Rennie, Penny Malone), Ken and Audrey de Grussa (Neridup), Owen and Terri Brownley (Mt Madden).

GRDC Project No.: DAW 722

Paper reviewed by: Matthew Ryan

Variety release and End Point Royalties – a new system?

Tress Walmsley, Department of Agriculture, Western Australia

KEY MESSAGES

Department of Agriculture is reviewing its grain variety release process and method of collecting End Point Royalties and seeks input from the industry about the proposed methods.

VARIETY RELEASE

The Department is the major grain crop breeding organisation in WA, releasing on average four new varieties per year. The process used to release a variety can have significant impact on the uptake and life of the variety. In 2002, the Department introduced the 'Grower Direct' system and has made minor adjustments to this system over the past three years.

Objectives of the current variety release system

- Ensure rapid and maximum adoption of Department varieties.
- Create a competitive seed market to prevent high seed prices.
- Provide an opportunity for all levels of seed marketers to operate in WA.
- Ensure that quality seed is available for sale.

Proposed changes to current variety release system

The Department wishes to maintain the above objectives and add the following two additional objectives:

- The system must allow the Department of Agriculture and the other equity owners to receive acknowledgment and brand recognition for the varieties.
- Efforts of all the stakeholders should be recognised and each given the opportunity to receive equitable remuneration for their contribution.

The review process is investigating the following issues:

1. Open trading: The Department currently considers that the declaration of open trading (farmer to farmer trading) makes a significant difference to the adoption of varieties. An open trading environment dramatically decreases the seed price and substantially improves a grower's access to seed. Generally, the Department declares open trading after two to three years and this has a major impact in the market uptake of the varieties. Some industry bodies oppose the use of open trading on the grounds of the potential impact it may have on seed quality. The Department seeks additional feedback from the wider industry on the continued use of farmer of farmer trading.
2. Sharing End Point Royalties: Currently the Seed Licensee receives its financial return by adding a profit margin to the seed sales. Growers frequently state that the high price of seed as being one of the key barriers to rapidly adopting new varieties. The Department could establish a system where the Seed Licensee sold the seed at cost price and received an agreed share of the end point royalty.
3. Exclusive vs. non exclusive licenses: Many other breeding organisations offer exclusive licences and the Department is considering using an exclusive licence for future releases. This may extend to the selection of a long term exclusive partner for five years. The Department seeks feedback from the industry about their attitude towards to a long term exclusive licence and in particular what would be the negative effects of such a position.
4. Modification of the 'Grower Direct' system: If the Department elects to continue using its current grain variety release system, what are the issues that need to be resolved?

END POINT ROYALTIES

The majority of grain varieties released today attract an EPR but their implementation has been approached individually by each breeding organisation or collection agent. This has resulted in several relatively similar but separate systems operating within the industry. In December 2002, the Plant Breeders Right Act was amended, providing the opportunity for the grains industry to implement a more efficient EPR system.

Current EPR system

The EPR is collected from the grower of the crop. Summary of the process: At the point of purchasing seed of a PBR variety the grower enters into a contract. This contract authorises the deduction of an EPR. The grain trader deducts the EPR. Under a separate contract (sometimes included in the Seed Marketing Licences) this royalty money is returned to the PBR owner.

Each Breeding Organisation, Seed Licensee or EPR Collection Agent has established their own collection agreement, database and audit system. These systems track the movement of the seed / grain of each grower. The collection process costs between $0.12 to $0.50.

The current system has some legal issues such as third line forcing under the Trade Practices Act. AWB Seeds have successfully made a case on the grounds of public good but the immunity could be revoked at any time. As grain breeding becomes more commercially focused and private breeding organisations continue to enter the market, it is debatable if the public good argument can be sustained.

Proposed EPR system

Amendments to the PBR Act allows the grantee to exercise their right of authorisation for all acts under section 11. There are some specifications made for statutory marketing authorities but PBR grantees are still entitled to receive their remuneration. We now have the opportunity to impose the EPR at any point along the supply chain.

It is therefore proposed to have the EPR collected at the point where the grain traders first purchase the grain. All grain traders would be required to enter into contracts with the PBR grantee if they wish to trade grain of a PBR variety. These contracts will provide authorisation to trade in the PBR variety in return for remuneration (i.e. the EPR).

The grower does not need to be involved in any point of seed sale contracts. The new system will require some audit process and the administration of contracts with every grain trader in Australia but it would not need to be as large and complicated as the current system.

INDUSTRY CONSULTATION

The Department seeks industry comment on the above concepts. **All responses must be in writing and received by 7 March 2005**. Please provide your name and your relationship to the industry, i.e. grower, seed producer, licensee, lobby group). Please send your responses to: Tress Walmsley, Department of Agriculture WA, RSM 184, BUSSELTON WA 6280 or Fax: 08 9753 1068, or twalmsley@agric.wa.gov.au.

KEY WORDS

variety release, end point royalties, commercialisation

Paper reviewed by: Keith Alcock

Farming system analysis using the STEP Tool

Caroline Peek and **Megan Abrahams**, Department of Agriculture, Western Australia

KEY MESSAGES

The STEP (Simulated Transitional Economic Planning) computerised decision aid is a transitional farming model designed to help users investigate the financial consequences of changing a farming system. The user can progressively track whole farm cash flows through the transition from the current to the new farming system for periods up to 50 years. Inputs into STEP are by the user. The accuracy of the analysis is determined by the quality of the input information.

HOW IS STEP SET UP?

Setting up the farm is the most critical part of STEP. The model is an Excel workbook and consists of a setup sheet, land management unit sheet, livestock sheet, budget sheet, farm summary sheet and graph sheet.

Setup sheet: The user chooses how the farm is divided into different Land Management Units (LMU's). These are areas of land which have the same initial rotation and production characteristics and will eventually either move into the same future rotation or remain in the initial rotation. These could be groups of paddocks or an individual paddock.

Gross Margin information for each enterprise is also required. This includes a code for each crop and pasture type along with yield, price and the associated variable costs and a pasture and stubble stocking rate if grazed. This is done for all current and future parts of the rotations including establishment years. These can be modified and added to during the analysis. The model also caters for up to eight different livestock enterprises. These are entered along with input costs, reproduction per cent, death rates, production details and prices for each type and class of animal.

Land Management Unit sheets: The model generates a separate sheet (Table 1) for each of the land management units nominated in the setup sheet. This is where you enter all the current, future and transitional rotation sequences and the model will automatically generate rotation sequences for each paddock over the nominated period of time. The yields and input costs of crops and pastures can be changed either in the setup sheet or in this LMU sheet (Table 1). Table 1 demonstrates the simulation of the introduction a of serradella-sub. clover pasture (pleg)/wheat rotation to replace the current lupin/wheat rotation on 2 paddocks within the grey sand land management unit.

Stock sheets: The model generates a stock sheet for each livestock enterprise nominated in the setup sheet. The annual and winter carrying capacities for the whole farm is calculated from the rotations and stocking rates in the LMU sheets. This information flows into the stock sheets where livestock numbers can be set to match the capacity of the farm. If the farm is running a self replacing livestock enterprise the user can input current stock numbers and the model automatically generates a self-replacing structure over the period of analysis. These numbers are changed manually if carrying capacity changes occur within a transition period. Animals can be bought and sold, or transferred into other separate livestock enterprises on the farm. The model also has the facility of an up breeding button to automatically track numbers of first cross, second cross etc animals if you are developing a new breed from the current breed. Yields and incomes of products such as wool, leather, etc. are also calculated automatically in these sheets and transferred to the budget sheet.

Table 1. The Land Management Unit worksheet. The rotation simulation table is automatically generated from user inputs into the rotation and sub unit information. The expander buttons (+) allow you to expand each table and make changes to the input costs and yields of each crop or pasture

greysand Land Management Unit. Run Simulation

Rotation Information

Enterprise Letter Code Reminder.

Enterprise	Wheat	Wpvol	Canola	Lupins	legpast	estabp	Wcadiz	shspra	Wlate	.wetsoi	shbroa	tramlir	tramlir	Wtraml	Czseec	rmanur	bmanu
Enterprise code (eg W)	W	Wpvol	C	L	pleg	pnew	wcad	lss	wlate	lws	lsb	wtr	ctr	wtrl	czs	pbman	wbm

Current Rotation. Choose the rotation using the enterprise codes listed above. The rotation cell background will turn dark blue if a letter that d

Sequence Year	1	2
Enterprise	w	l

Future Rotation. Are you changing to a new rotation? If yes, fill in the future rotation.

Sequence Year	1	2	3
Enterprise	w	pleg	pleg

Transition Years. Are there a number of expensive years of transition moving into the future rotation? If yes, fill in the transition years.

Sequence Year	1	2	3
Enterprise	pnew	pleg	pleg

Sub Unit Information

Total Farm Ha 3500
Total LMU Ha 500

Sub Unit Names	ha	Sequence yr in	Transition yr (eg	Include transition yrs?
Paddock 1	50	1		
Paddock 2	200	2	2006	1
Paddock 3	100	1	2007	1
Paddock 4	150	2		

Simulation

Rotation Simulati	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Paddock 1	w	l	w	l	w	l	w	l	w	l
Paddock 2	l	w	pnew	pleg	pleg	w	pleg	pleg	w	pleg
Paddock 3	w	l	w	pnew	pleg	pleg	w	pleg	pleg	w
Paddock 4	l	w	l	w	l	w	l	w	l	w

Budget sheet: The information generated in the LMU and stock sheets is transferred into the budget sheet. A total income and income from each enterprise is presented, as is total expenditure and itemised variable costs (fertilisers, sprays, etc.). The user enters the annual fixed and capital costs for each year. Taxation can also be calculated along with overdraft interest. **An annual surplus or deficit and a cumulative financial position for the business is generated.**

Farm summary sheet: This sheet calculates the Net Present Value of the cumulative position and the annual surplus/deficit. The effects of declining terms of trade on the farm business can be simulated by increasing costs and returns at different rates. Total annual tonnage of each crop, hectares of each crop and pasture phase and total winter and summer livestock numbers are also presented. Variable, total, fixed and capital income and expenditure per hectare is also found here.

HARDWARE/SOFTWARE REQUIREMENTS

The STEP tool requires a copy of Excel 97 or later to run. Before the simulation is run to compile the working sheets it is less than 1 MB and will fit on a 3½ inch floppy disk. After the model has been entered it is unlikely STEP will be less than 2 MB and so requires analysis to be done on a hard disk.

ACKNOWLEDGMENTS

Anne Bennett, Alan Herbert, David Rogers, DAWA, integral in the design and development of STEP. GRDC, NDSP 'A Million Hectares for the Future' and NHT funding ensuring the development of STEP.

Project No.: GRDC DAW 660, NHT 963001, DAWA RSM/LRQ

Paper reviewed by: Christopher Carter and Alan Herbert

The Leakage Calculator: A simple tool for groundwater recharge assessment

Paul Raper, Department of Agriculture, Western Australia

KEY MESSAGES

- Minimisation of groundwater recharge is one of many strategies that grain growers can employ to manage their salinity risk.
- Well-drained soils generally have a higher potential for recharge control than less permeable soils.
- The decision whether to adopt recharge control as a salinity management strategy requires consideration of biophysical and economic impacts. The Leakage Calculator is a simple tool to help landholders assess the biophysical aspects of the decision. Other tools are available to help with economic aspects of the decision.

AIMS

The Leakage Calculator was developed to help farmers and their advisors quantify the amount of water leaking past the root zone of agricultural plants with a view to tailoring recharge minimising strategies for salinity management. It is assumed that other salinity management strategies are considered and employed, where appropriate.

METHOD

Completing a soil water balance for a catchment or farm requires information on the soils, climate and management of the area and a method of calculating the losses of water from the soil. The Leakage Calculator is a simple spreadsheet in which the calculation of runoff, evaporation, transpiration and deep drainage (leakage) have already been performed using the Department of Agriculture soil water balance model, AgET. There are seven versions of the Leakage Calculator, each representing an area of the south-west agricultural region. The model was developed to be used in a series of salinity management workshops but constitutes only a small fraction of the material covered in the workshops. Therefore, it was designed to be used by non-specialist presenters with little or no training.

Data on the relative distributions of LMUs over the area represented by each Leakage Calculator and on the physical properties of the dominant soils in each LMU were extracted from the Department's map unit database. Bureau of Meteorology rainfall and pan evaporation data for selected sites in the south-west agricultural region are distributed with AgET. Crop data was collected from published sources and expert knowledge. AgET was calibrated so that predicted leakage rates were in general agreement with average regional rates of groundwater rise because this is the model output of primary interest in developing the Leakage Calculator.

Each Leakage Calculator consists of six worksheets, the first is a coversheet and the last is an information page detailing the soil types represented. There are four calculation worksheets, which the user steps through in turn. The first two of these present the leakage results in volumetric terms, that is, in millimetres of water and as a percentage of mean annual rainfall. Leakage results displayed in both these worksheets are colour coded. The third worksheet in each Leakage Calculator requires the user to enter the area of each LMU under each plant type. Areas may be input as per cent, hectares or acres and the areas of each LMU mapped in the region are supplied as a guide. There is also a calculator for converting the length and numbers of rows of trees in alley plantings to an area.

The final worksheet presents the volumes of leakage generated from each LMU – plant combination specified. The figures are colour coded in the same manner as the leakage rates shown in the first two worksheets. The user is required to enter the volume of an average farm dam; this is used to express the total leakage for the farm as a number of farm dams. The result is displayed in this way to highlight the volume of water involved and to encourage landholders to view it as a resource.

Example results

Figure 1 shows the leakage from a hypothetical 2,500 ha farm at Cunderdin. Sixty per cent of the farm is under crop. The greatest leakage volumes under the selected management come from the more permeable soils. Together the poorer upland sands account for 73% of the estimated leakage but only 33% of the farm area. Serradella pasture and lucerne are selected on 180 ha and 50 ha of these soils, respectively, but these areas are small in relation to the total area of permeable sands (815 ha).

Total leakage under the farm is in excess of 424,000 m^3. If the average dam volume for the area is 4,000 m^3, then this equates to over 100 farm dams of water being lost to productive purposes each year; a massive volume of water to dispose of if discharge management were to be the only salinity management strategy adopted. To put the value of the volume of water into perspective, it would cost in excess of $614,000 a year to use that much scheme water. In this example increasing the areas of serradella and lucerne to 200 ha and 260 ha, a doubling of the area of perennials on the permeable soils, would lead to a 14% reduction in leakage over the whole farm area.

Central Wheatbelt	
Soil-Landscape Zone	258
Representative Location	Cunderdin
Mean Annual Rainfall (mm)	370

Plants

B	bare soil
C	cereals & pulses
P	annual pasture
Se	serradella
G	perennial grasses
Lu	lucerne
OM	oil mallees
S	salt bush

Blue-on-blue boxes can be edited
Turquoise boxes contain results of calculations
Orange boxes contain information to use as a guide
Leakage is colour coded
High Leakage - greater than 25% of total leakage
Moderate Leakage - 10% to 25% of total leakage
Low Leakage - less than 10% of total leakage

Input the volume of an average farm dam 4,000 cubic metres

Option 2 - Areas input in hectares

Land Management Unit	Actual % Area	LMU x Plant - Leakage Volumes (cubic metres)							
		B	C	P	Se	G	Lu	OM	S
Poor sands	16.2	0.0	99,000.0	0.0	79,200.0	0.0	0.0	0.0	0.0
Average sandplain	16.4	0.0	133,200.0	0.0	0.0	0.0	4,000.0	0.0	0.0
Good sandplain	12.0	0.0	36,400.0	0.0	0.0	0.0	200.0	0.0	0.0
Shallow duplex soil	13.6	0.0	10,800.0	6,500.0	0.0	8,500.0	0.0	0.0	0.0
Medium heavy	12.4	0.0	8,400.0	0.0	0.0	5,500.0	0.0	0.0	800.0
Heavy valley floors	18.0	0.0	7,200.0	4,800.0	0.0	0.0	0.0	0.0	0.0
Sandy surfaced valleys	8.4	0.0	13,000.0	0.0	0.0	0.0	0.0	0.0	0.0
Deep duplex soil	3.0	0.0	6,800.0	0.0	0.0	0.0	0.0	0.0	0.0

Total Leakage 424,300 cubic metres
Equivalent to 106 4000 cubic metre dams

Figure 1. 'Volumes' worksheet of the Central Wheatbelt Leakage Calculator showing colour-coded leakage volumes and total leakage for a 2,500 ha farm in cubic metres and in relation to the volume of an average farm dam.

CONCLUSION

The Leakage Calculator is a very simple tool that allows farmers and their advisors to appreciate the volumes of water that leak past the root zone of common agricultural plants. It allows one to identify the areas that contribute the most water to the groundwater system both in absolute and per unit area terms. The model has limitations in that plants grown in rotations are not considered and there is no spatial context to the areas assigned to different LMUs or plants.

KEY WORDS

leakage, salinity, recharge, groundwater

ACKNOWLEDGMENTS

The Leakage Calculator was developed as part of the Million Hectares for the Future project and all staff involved in the project contributed. Richard O'Donnell and Tom Sweeny developed the original Leakage Calculator. Peter Tille and Dennis Van Gool provided access to the map unit database and much invaluable advice on soil properties. Members of the Catchment Hydrology Group provided data to use in the calibration of AgET.

Project No.: DAW 660
Paper reviewed by: Richard O'Donnell

NB: There is an extended version of this paper on the Crop Update 2005 CD.

The Cost of Salinity Calculator – your tool to assessing the profitability of salinity management options

Richard O'Donnell and **Trevor Lacey**, Department of Agriculture, Western Australia

KEY MESSAGES

- Any salinity management option needs to be around 80%+ as profitable as the current land use. Of the 13 options suggested, Broombush, Firewood and Softwood sawlogs are the only three options that do not have the potential to reach this minimum.
- There is a wide variation in the level of profitability between the salinity management options so take the time to assess the management and environmental factors (time, labour, rainfall, soil characteristics) that will influence the viability of the chosen salinity management option(s).

AIMS

Salinity Management Option(s) (SMOs) are land use options likely to be adopted if they achieve one of the following:

1. Allow conventional agriculture to continue, e.g. surface water management and deep drains.
2. Complement conventional agriculture, e.g. grazing value from salt land, perennial grasses and lucerne pastures; or
3. Provide an alternative income source e.g. oil mallees, maritime pine and firewood.

The Cost of Salinity spreadsheet calculator is to compare income that will be lost to the farm if salinity is allowed to develop at its current rate with delaying the onset of salinity by implementing management changes. This is specific to the broad flat valley floors of the Central and Eastern Wheatbelt of Western Australia.

Hence, this paper aims to determine the economic value of SMOs, specifically the profitability of the option compared to the current land use, through use of the Cost of Salinity calculator and a desktop study of SMOs currently in use.

METHOD

The desktop analysis of the profitability range of 13 SMOs considered for Western Australia (Table 1) was conducted to provide a guide for the '% profitability compared to the current land use' variable in the Cost of Salinity calculator.

To simplify the results generated, this analysis used three values for '% profitability compared to the current land use' (100%, 80% and 60%) in combination with three values for 'land that will go saline on the farm' (15%, 20% and 25%).

Table 1. A selection of SMOs considered for West Australian agricultural landscape to delay the onset of salinity. Included in the table are indicative profitability ranges for incorporating these SMOs into the whole farm budget

Salinity management option	% profitability range	Comments Figures on whole farm basis (net profit)
Broombush	41–52%	-$78 to -$67/ha/yr*
Cell grazing	150%	$42/ha/yr*
Deep drains	70–131%	$15 to $28/ha/yr
Firewood	44%	-$92/ha/yr*
Hardwood sawlogs	68–147%	-$117 to -$17/ha/yr*
Jojoba	183%	$69/ha/yr*
Lucerne	72–157%	-$4 to $188/ha/yr*
Native pasture cropping	114%	$20/ha/yr*
Oil mallees	64–251%	-$1 to $106/ha/yr*
Perennial pasture	-409–1838%	-$4 to $296/ha/yr*
Saltland pastures	102–108%	$2 to $113/ha/yr*
Softwood sawlogs	33–41%	-$92 to -$67/ha/yr*
Surface Water Management	42–172%	$6 to $23/ha/yr

* Indicates inclusion of Eastern States analysis figures due to minimal or lack of Western Australia analysis.

Users of the Cost of Salinity Calculator need four basic sources of information to modify the calculator to provide results localised to their situation (Table 2). This information can be changed singularly or in combination to provide different results to several 'what if' scenarios.

Table 2. Information required by the user of the Cost of Salinity Calculator

Variable inputs (changeable by the user)	Sources of input data
The farm size in hectares	Own records
Future salinity as a % of the farm size	Land Monitor maps, Catchment reports from local Community Landcare Coordinators or similar
Current profitability of the land at risk	Bankwest Benchmarks or own records
Profitability of the SMOs as a % of current land use	See Table 1

The output values are cumulative profitability in dollars for the farm for the time periods 20, 50, 75 and 115 years after implementation of the SMO(s). A positive output value is the profit above the current land use value over the time frame whilst a negative output value is the profit foregone by not implementing SMO(s) to delay salinity development.

RESULTS

From the combination of variables detailed in the previous section, the following values were generated by the Cost of Salinity Calculator (Table 3).

Table 3. Results from the Cost of Salinity Calculator. Farm size of 2000 ha, current land use profitability of $100/ha. Negative values indicate the farm is losing money due to loss of land to salinity

Scenario	Profitability of the SMOs as a % of current land use	Farm profitability value by introducing SMO(s) above the current land use value ($)			
		20 years	50 years	75 years	115 years
15% salinity	100%	$66,500	$227,800	$367,700	$440,000
	80%	$6,500	$107,800	$187,700	$164,000
	60%	-$53,400	-$12,200	$7,700	$112,000
20% salinity	100%	$88,800	$303,800	$490,200	$586,600
	80%	$8,800	$143,800	$250,200	$218,600
	60%	-$71,250	-$16,200	$10,200	-$149,400
25% salinity	100%	$110,900	$379,700	$612,800	$733,300
	80%	$10,900	$179,700	$312,800	$273,300
	60%	-$89,100	-$20,300	$12,800	-$186,700

The most obvious trend noted was that the SMO(s) chosen needed to be around 80% or better than the profitability of the current land use for it to be considered beneficial to the whole farm profitability. Any SMO(s) that are below 80% as profitable as the current land use don't provide much appeal for adoption when it would be easier to continue with current practices and accept that a percentage of the farm will go saline and hence, be unavailable for conventional agriculture in the future.

CONCLUSION

Based on the above results, 10 of the 13 SMOs suggested for the Western Australian agricultural landscape (Table 1) have the potential to contribute to the overall profitability of the chosen farm. It appears that Broombush, Firewood and Softwood sawlogs have percentage profitability ranges below the minimum requirements. More analysis of these SMOs, especially West Australian examples, will develop the confidence in the profitability figures gathered to this point in time.

KEY WORDS

salinity, management, calculator, profitability

ACKNOWLEDGMENTS

This calculator was developed for the DAWA/GRDC/NDSP funded '*A Million Hectares for the Future'* workshop series which deals with dryland salinity and key management options.

GRDC Project No.: DAW 660

Paper reviewed by: Paul Raper

NB: There is an extended version of this paper on the Crop Update 2005 CD.

Climate decision support tools

Meredith Fairbanks and **David Tennant**, Department of Agriculture, Western Australia

KEY MESSAGES

Computer software programs have been developed by the Department of Agriculture (DAWA) which promises to take some of the guesswork out of risky farming decisions. These decision support tools provide information about plant available water, potential yields, seasonal rainfall, flowering time, temperature events and climate analyses to help farmers make more informed strategic and tactical decisions.

Potential Yield Calculator

The Potential Yield Calculator, widely referred to as PYCAL, was developed in the 1990s to calculate potential yields and water use efficiencies for wheat and other crops. These were used to provide benchmarks for assessing production efficiency in high yield cropping packages.

Key features of PYCAL are:

- Estimates plant available water from summer rainfall.
- Compares current season rainfall against earlier years and against long term decile rainfall totals.
- Calculates potential yield for all crop types using French and Shultz equations.
- Calculates likelihood of achieving sufficient rainfall to achieve target yields.
- Calculates production efficiency against benchmarks in answer to the question – could I have done better?

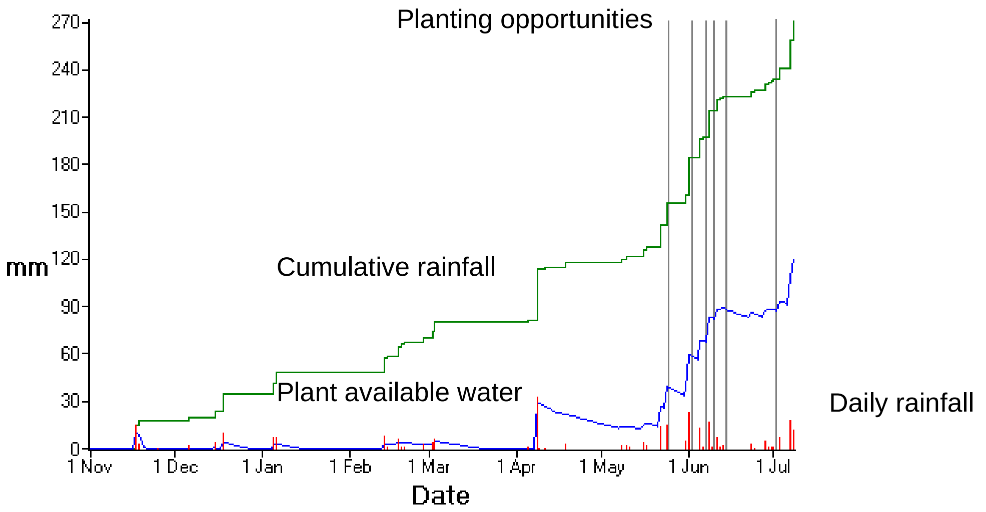

Figure 1. Output from PYCAL showing the cumulative rainfall, cumulative plant available water, daily rainfall and planting opportunities from 1 November 2003 to 8 July 2004 for Merredin

Flowering Calculator

The Flowering Calculator was developed in the mid 1990s to estimate flowering time and incidence of suitable temperatures for pod set (critical temperatures), frost and damaging high temperature events for any date of sowing.

Key features of Flowering Calculator are:

- Calculates flowering time for any date of sowing and crop variety using average regional temperatures and day length.
- If local temperature data are available, it can be used to determine the time in the growing season when temperatures are suitable for pod set, when frost incidence is at its lowest and when damaging high temperature events occur.

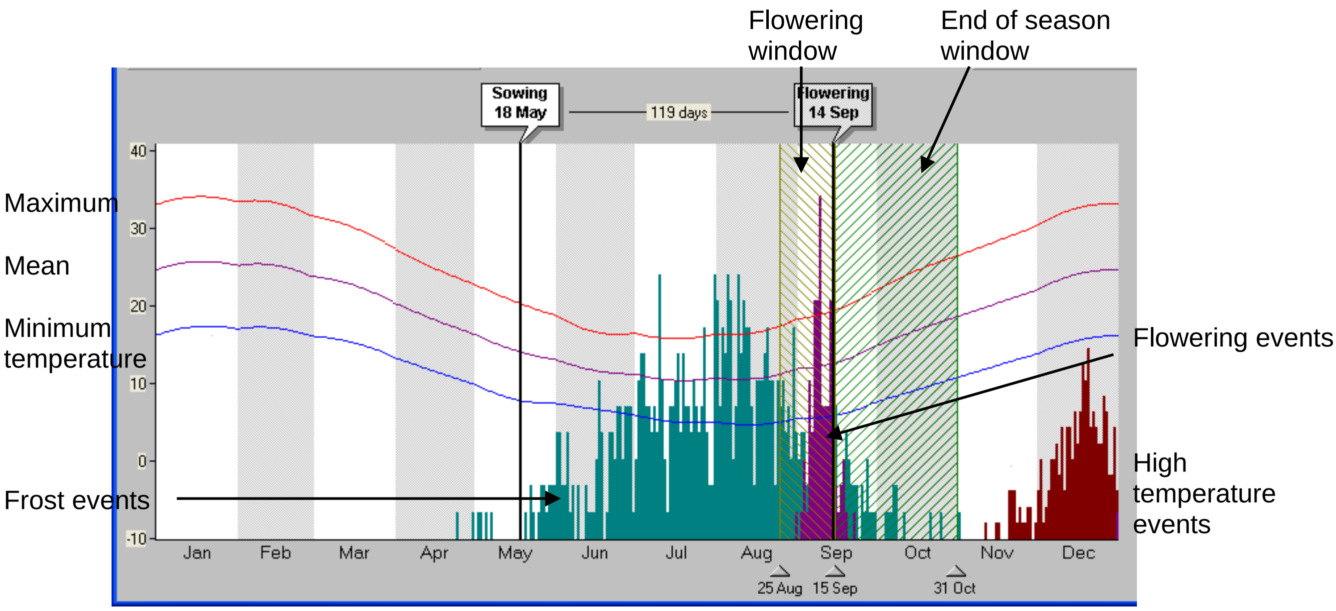

Figure 2. **The Flowering Calculator is used to compare varieties to find the one which flowers within the flowering window and has the lowest probability of frosts and high temperatures. This figure shows the flowering time for Eradu wheat when sown on 18 May in Merredin.**

Climate Calculator

The Climate Calculator was developed in the early 2000s to display and analyse climate information. It can be used to analyse historical climate information and the probability of climate risks in relation to strategic and tactical farm management decisions.

Key features of Climate Calculator are:

- Graphs data against decile data for any location or against other years.
- Calculates growing season and summer rain deciles.
- Finds past years with similar rainfall amounts or patterns.
- Selects particular climate events defined by the user.
- Finds linkages between climate parameters.

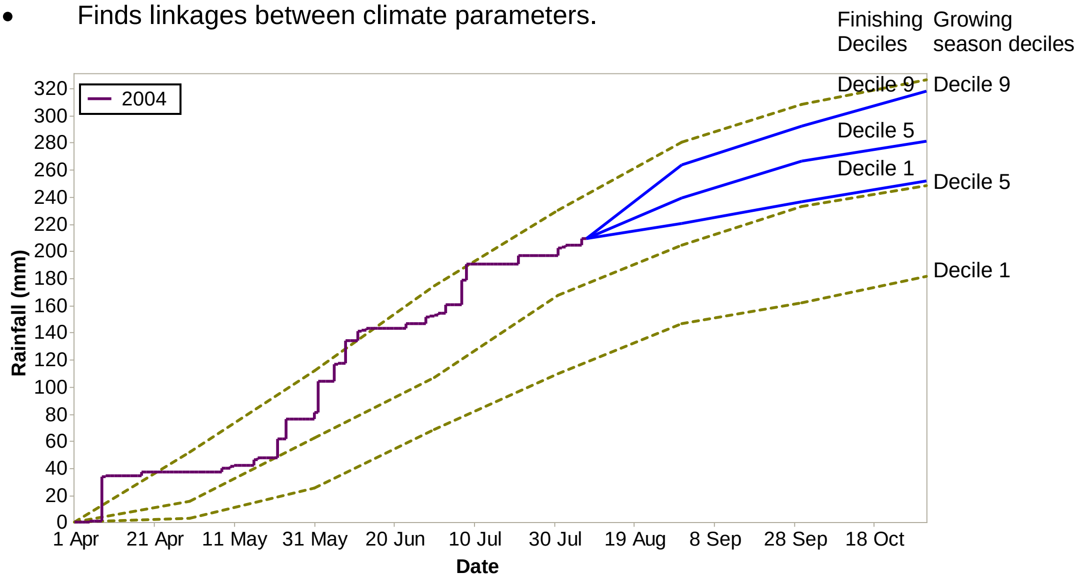

Figure 3. **Climate Calculator graph with rainfall to 7 August 2004 for Merredin indicating that even with a decile 1 rainfall finish, the growing season rainfall will still be above average (decile 5). This information can help you make tactical decisions.**

ACKNOWLEDGEMENTS

Financial support from GRDC.

Project No.: DAW00040

Paper reviewed by: Geraldine Pasqual

Horses for courses – using the best tools to manage climate risk

Cameron Weeks, Mingenew-Irwin Group/Planfarm and **Richard Quinlan**, Planfarm Agronomy

KEY MESSAGES

- Managing seasonal or climatic risk is primarily about yield forecasting!
- PYCAL (potential yield calculator) and APSIM (agricultural production simulation model) are decision support tools that can assist with in season yield forecasting.
- Both PYCAL and APSIM are very different tools yet both need some local calibration to achieve a reasonable level of accuracy.
- At Mingenew/Irwin in 2004 both PYCAL and APSIM did not accurately predict yield.
- There is no reason why APSIM should not be able to more accurately simulate yield once it is better calibrated.
- In 2004 two N prediction models (SYN and NULogic) overestimated N requirements.

BACKGROUND

Managing climatic or seasonal risk is one of the biggest challenges facing farmers each year. The nature of much of the wheatbelt is such that seasonal rainfall and thus yield potential fluctuates from season to season. The challenge for growers is to be able to manage this fluctuation so that they can capitalise on the 'good' seasons and minimise 'the damage' in the poor seasons.

The Mingenew-Irwin Group is working on a project funded by the Managing Climate Variability Program which sees it testing a range of decision support tools to see if they, or combinations of them can assist growers to better manage the vagaries of the season.

AIMS

1. To compare a range of tools that can assist with better management of climatic risk.
2. To figure out exactly if and how these tools or combinations of tools can lead to better management of climatic risk.
3. If deemed to be of 'value', determine how the tools and outputs from the tools need to be packaged or presented.

METHOD

In 2004 11 sites were selected across the Mingenew-Irwin district from west to east covering a wide range of soil types and production environments. At each of these sites information was gathered allowing a range of decision support tools to be operated providing information throughout the growing season for farmers.

The tools used in 2004 included:

Yield forecasting

- APSIM (agricultural production simulation model).
- PYCAL (potential yield calculator based on French-Schulze yield potential formula).

Nitrogen forecasting

- SYN (select your nitrogen).
- NULogic (CSBP).

Soils at each site were characterised to understand plant available water capacity (required by APSIM). PYCAL was calibrated at each site based on local (the paddock in question) historical water use efficiency.

Throughout the growing season a bulletin was sent to members of the Mingenew-Irwin Group providing up to date yield forecasts along with nitrogen recommendations to achieve these yields.

Included in the bulletin was a summary of the up to date Bureau of Meteorology (BoM) and Dept. of Agriculture, WA (DAWA) climate outlook.

Nitrogen trials were located at six of the eleven sites to allow retrospective analysis of the performance of the N tools.

RESULTS

Yield forecasting

Table 1. PYCAL and APSIM calculated yields based on 'actual TOTAL' rainfall at 5 of the 11 sites. The actual yield is the yield recorded in the paddock by the farmer

Property	Soil type	GSR (mm)	PYCAL (t/ha)	APSIM (t/ha)	Actual (t/ha)
Heitman	Red sandy loam	228	2.5	1.4	2.5
Holmes	Red loam	260	2.1	1.4	2.9
Forward	Pale sand	356	1.5	2.7	2.4
Foster	Sand over gravel	401	2.6	2.4	4.2
Gillam	Cracking clay	359	3.0	3.1	5.2

APSIM

At 10 of the 11 sites APSIM forecast yields significantly below what actually occurred. To calibrate APSIM for a particular site the soil needs to have its plant available water holding capacity measured. This was done for all sites. It appears that the function in the model which simulates plant rooting depth in the soil profile needs to be adjusted to better reflect yield.

PYCAL

The standard calibration for PYCAL is 15 kg/mm/ha water use efficiency. In 2004 we calibrated PYCAL by analysing recent 'water use efficiencies (WUE)' for all sites. WUE's in 2004 tended to be very good (often 15–20 kg/mm/ha). Essentially the even distribution of not overly abundant rainfall saw the plant use water extremely efficiently. This in turn saw PYCAL under estimate yield at most sites.

By calibrating for each individual site the water holding capacity of the soil as well as the farmers skill level are taken into account.

Nitrogen forecasting

Broadly speaking both SYN and NULogic overestimated the amount of N required to achieve forecasted yields at the 11 sites. The 6 N trials carried out showed none of the sites were N responsive (even at yields as high as 5.2 t/ha).

CONCLUSIONS

APSIM

- Is not easy to calibrate (soil water holding capacity and plant rooting depth!).
- Needs someone to dig deep holes!
- Is complex and data hungry and therefore could only be delivered to farmers at a substantial cost!
- BUT it is possible for it to be used and its outputs presented in a user friendly fashion – 'Yield Prophet' (Birchip Cropping Group/CSIRO).
- Simulates yield for a specific 'piece of dirt'.

PYCAL

- Is a very useful tool, which when compared to APSIM is very simple to use.
- BUT it's major weakness when being used as a yield forecasting tool is that it does not take into account leakage of water out of the soil profile. Therefore the only way to calibrate is to adjust the WUE (i.e. kg/mm/ha).
- Calculates yield potential (as opposed to APSIM which calculates likely yield).

- Can provide an estimate of yield potential for a whole paddock rather than a specific ‘piece of dirt’.

Nitrogen

- Is the major crop input that can be varied once the crop is sown. The required rate is also largely determined by the crop yield potential.
- N requirements in 2004 were overestimated by both SYN and NULogic. It should be added though that the recommendations put out by both tools (broadly speaking) were fitting with agronomic advice provided by local agronomists in 2004.

General

- Physically incorporating a climate outlook into yield forecasting is possible (i.e. historical rainfall data can be sorted based on certain SOI phases) but in Western Australia we are unsure as to how this can be best achieved.
- Sound yield forecasting is most needed where yield/rainfall variation from season to season is greatest.

Playing the season

- ‘Playing the season’, is the key to better managing seasonal/climatic risk! To do this crop yield needs to be forecast at numerous times throughout the season.
- The basic principles of yield forecasting are: 1. understanding stored plant available water at a given point in time; 2. ‘likely’ rain to come (historical rainfall records – deciles); and 3. reading the crop (plant density, tillers, weeds, disease, etc.).
- With a good understanding of these three factors it is possible for a sound estimate of likely yield to be made without the aid of a decision support tool. That said if you require more than just an estimate of likely yield then there are tools such as PYCAL and APSIM that may be for you.

Horses for courses

- The different tools available to farmers are essentially different ‘horses’. Before a farmer can decide on which ‘horse’ they would like to ride they need to ask them selves which ‘course’ do I wish to travel? That is - what are my information requirements?

2005

- In the coming season MIG will again be providing a Horses for Courses Seasonal Outlook bulletin on a monthly basis. This season though, members will be asked to nominate two sites that are of interest to them. These will be emailed directly to the member. The remaining site forecasts will be available on the MIG website.
- The content/layout of the bulletin will be altered based on feedback during 2004.
- We are confident that APSIM will be better calibrated and producing yields more fitting with what is expected.
- Further N trials will be carried out to test the accuracy of the SYN and NULogic recommendations.
- Farmers will be surveyed to determine the usefulness of the information being provided, whether or not the information led to changes in crop management and if so what was the result.

KEY WORDS

APSIM, PYCAL, SYN, NULogic, yield forecast, climate, nitrogen

ACKNOWLEDGMENTS

The funding for the project is provided by the Managing Climate Variability Program. MIG, CSIRO, DAWA, Planfarm Agronomy, Elders and CSBP are all partners in the project.

Project No.: Land and Water MIG1

Paper reviewed by: Peter Newman, Department of Agriculture

Use of seasonal outlook for making N decisions in Merredin

Meredith Fairbanks and **Alexandra Edward**, Department of Agriculture, Western Australia

KEY MESSAGES

By making use of DAWAs Global ENSO Sequence System (GESS) seasonal outlooks farmers can plan their N applications tactically. This study showed that applying the right level of N in the right season is more profitable than applying N appropriate to an average season.

AIM

To demonstrate that DAWA's prototype Global ENSO Sequence System (GESS) seasonal outlooks can be helpful in making tactical decisions on N application.

METHOD

DAWA provides a growing season outlook in February with monthly updates. These outlooks include identification of five analogue years, which are selected by GESS through pattern matching of ocean and atmosphere signals in the current and previous years. The median (middle) analogue year potentially provides a pointer to rainfall for the coming year.

DAWA's decision support tool SPLAT (Season Protein Likelihoods and Tradeoffs) is an Excel based tool, which predicts possible yields and proteins for a range of season types given wheat variety, nitrogen rate and sowing date. Here SPLAT was used in hindcasting mode, to analyse three scenarios in the 2002, 2003 and 2004 Merredin growing seasons on light and heavy (duplex) soil. The three scenarios analysed were: 1. The 'Average' farmer – planning for a median year (decile 5) growing season; 2. The GESS farmer - planning on receiving the same rainfall decile as the GESS derived median analogue year; 3. The 'Perfect Knowledge' farmer – planning with perfect knowledge of the year ahead.

RESULTS AND DISCUSSION

2002

The GESS median analogue was a decile 3 year, and the 2002 actual growing season rainfall was decile 1. SPLAT indicated that an Australian hard wheat variety (AHard) would be best in a dry season with a late start (16 June sowing date – source PYCAL).

SPLAT indicated that no additional N on light soil would give the best return in the GESS decile 3 year, but a loss of $5 /ha in the actual decile 1 year. The average farmer would have applied the SPLAT indicated N rate of 10 kg/ha and lost $15 /ha. The farmer with prefect knowledge would not have sowed. On heavy soil, SPLAT indicated a loss for a GESS farmer and the 'Perfect' farmer, and consequently these farmers would not have sowed on heavy soil. Even when SPLAT indicated no additional N, the average farmer would have lost $69 /ha on heavy soil (Table 1).

Table 1. Decisions on nitrogen applied and gross margin (GM) return using SPLAT for Merredin in 2002, 2003 and 2004 on light and heavy soil. *Assumes would not have sown

Rainfall outlook	Light soil			Heavy soil		
	N applied (kg/ha)	Expected GM ($/ha)	Actual GM ($/ha)	N applied (kg/ha)	Expected GM ($/ha)	Actual GM ($/ha)
	2002					
Average (decile 5)	10	66	- 15	0	49	- 69
GESS (decile 3)	0	40	- 5	0	- 7	0*
Perfect (decile 1)	0	- 5	0*	0	- 69	0*
	2003					
Average (decile 5)	70	169	215	30	124	214
GESS (decile 6)	100	200	230	50	173	219
Perfect (decile 7)	100	230	230	80	235	235
	2004					
Average (decile 5)	60	230	259	30	185	243
GESS (decile 3)	40	167	235	0	33	195
Perfect (decile 6)	70	262	262	40	245	245

2003

For 2003, the median GESS analogue year was decile 6, while the actual growing season rainfall was decile 7. SPLAT indicated that a short season APW wheat variety (18 May sow date) would give the best return.

By applying the SPLAT indicated 100 kg/ha N on light soil, the GESS and 'Perfect' farmers received the best return and $15 /ha more than the average farmer who applied 70 kg/ha N. On heavy soil, SPLAT indicated that a N rate of 50 kg/ha would give the best return in the GESS decile 6 year, which was $5 /ha more than the average farmer, who applied 30 kg/ha N, and $16 /ha less than the 'Perfect' farmer who applied 80 kg/ha N (Table 1).

2004

The GESS median analogue year was decile 2, while the actual 2004 growing season was decile 6. SPLAT indicated that a short season AHard variety would give a better return than an APW medium variety for a 25 May sowing date.

The average farmer, on the light soil, would have applied the SPLAT indicated 60 kg/ha N. As it was a decile 6 year, they would have received $24 /ha more than the GESS farmer, having applied the best rate of N for a decile 2 year (40 kg/ha N). By applying 70 kg/ha N, the 'Perfect' farmer would have received $27/ha and $3/ha more than the GESS and average farmers, respectively. SPLAT indicated for a GESS decile 2 year that no additional N on the heavy soil would have given the GESS farmer the best profit, but in a decile 6 year, the GESS farmer would have received $48/ha less than the average farmer who would have applied 30 kg/ha N, and $50/ha less than the 'Perfect' farmer who would have applied 4 0 kg/ha N (Table 1).

Although GESS in February 2004 selected a median analogue decile 2 year when it turned out to be a decile 6 year, farmers can make adjustments up until sowing as seasonal conditions become clearer. A study by Mjelde *et al.* (1998) found that there were significant potential gains for USA maize producers from making less accurate seasonal forecasts available early rather than more accurate forecasts available late.

Timing of N application is now becoming more flexible with the introduction of liquid N, so farmers might elect to split N applications so they can react to the season as it unfolds. Analysis with WA Wheat (APSIM) by Anne Bennett showed that later N application is generally more profitable. Anne looked at APSIM yields for 1900–2001 for Merredin and found no N at sowing followed by 50 kg/ha or 30 kg/ha at 4 weeks, on yellow deep sand or sandy earth, respectively, gives the best return. Later N application is beneficial for water use efficiency, as high N at sowing can lead to high crop vigour, depleting water reserves for grain filling (Passioura, 2004).

CONCLUSIONS

In 2 out of the 3 seasons, farmers using the prototype GESS seasonal outlook as delivered in February and managing N application accordingly would have been better off than those that managed for an average season. Benefits could be greater through making adjustments as the outlook becomes clearer as the season unfolds and by splitting N applications. However, the greatest benefits are likely from more strategic decisions such as whether or not to sow and on what soils to sow.

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ACKNOWLEDGEMENTS

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Project No.: DAW00040

Paper reviewed by: Miles Dracup

Forecasts and profits. Benefits or bulldust?

Chris Carter and **Doug Hamilton**, Department of Agriculture, Western Australia

KEY MESSAGES

Free climatic forecasting information is obtainable from the Department of Agriculture, WA website. However strategic and tactical responses by farmers are needed to turn it into extra cash income.

AIMS

The aim of this study was to determine the economic value of climate information on-farm, over a multi year period.

The study assessed financial outcomes for an average farm in a low rainfall area, over eight seasons (1997-2004) using 5 different management scenarios.

METHOD

The tool used to simulate these decisions and operations on farm was the STEP computerised decision aid (Peek *et al*. 2004). STEP allows the analyst to simulate a series of annual cash flows and track the progressive financial outcomes. The chosen spread of years gave a range of both good and bad seasons and allowed the use of actual rainfall and price data and publicised climate predictions.

The farm used in this study is a representative farm of 3,000 ha in the Mullewa shire. It is primarily a cropping system, with approximately 80% of the arable area in crop at any time.

Yields

Yields used in this study were based upon average yields within the shire. Yields were modified for the growing season rainfall, soil type and fertiliser regime in order to generate independent yield responses for each paddock over the course of the 8 seasons.

Farm management scenarios

The decisions made in regard to farm management for each year and seasonal scenario were simulated by a working group of DAWA officers involved with farmers from that area. The decisions were chosen on the basis of being representative of best farmer practice for the area.

Set rotation scenario (Set: In tables and graph)

In the set rotation runs, the decisions in farm management were limited. The rotations and inputs were set at what was determined to be the best agronomic practice for an 'average' season in the area and were not varied to account for the season.

Climate forecast use

There were three Management Scenarios evaluated when using the climate information.

1. Ability to change rotations and fertiliser input (C1 Both: In tables and graph).
2. Ability to change rotations (C2 Rota: In tables and graph).
3. Ability to change fertiliser input (C3 Fert: In tables and graph).

The management decisions using climate information were based upon three points of information:

1. GESS (Global ENSO Sequence System).
2. Summer rainfall (SSM).
3. The break of the season (timing, amount).

Perfect knowledge (Hind: In tables and graph)

Perfect Hindsight assumed knowledge of the rainfall distribution over the season. This allowed more rotation and input changes. This includes an optimal level of nitrogen application to provide the highest yields.

RESULTS

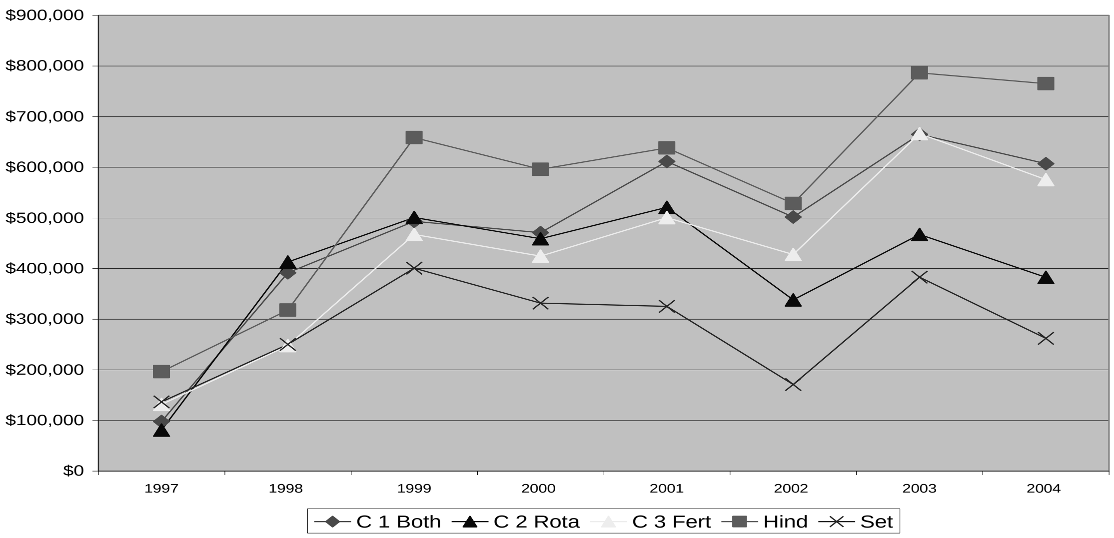

Figure 1. Comparison of Changes in Cumulative Cash Position. (zero balance at commencement of year 1).

The optimal farm management option is always going to involve perfect hindsight before making decisions – and therefore is a fictitious and unrealistic expectation. However, it demonstrates that changes in both rotation and fertiliser inputs are required to achieve maximum gains.

Table 1. Returns under management options and risk of a negative cash result

Management	Set	C2 Rota	C3 Fert	C1 Both	Hind
Av. closing cash balance	$32,760	$47,813	$71,963	$75,901	$95,656
Probability* of negative closing cash balance	40.6%	37.9%	28.8%	28.3%	27.6%

* Probabilities calculated from normal distribution.

CONCLUSIONS

This study showed there are economic benefits when using climate information if management responds by adjusting farm program and inputs. Although this simulation is of a model farm in a particular area the results, if not the scale of the results, should be applicable to farms with a similar system.

Changing both rotations and inputs according to climate data reduced the risk of negative seasonal returns.

Climate information will have value on-farm when used over multiple years. This will account for the inaccurate predictions and therefore some years when management response is inappropriate.

Changing rotations (only) on climate forecasts meant a higher level of risk than changing fertiliser inputs.

Set rotations meant the lowest financial returns and also the highest risk profile.

KEY WORDS

climate, economics, rotations, inputs

ACKNOWLEDGMENTS

John Borger was instrumental in the formulation of the study. We would also like to acknowledge the help of Caroline Peek, and the climate group including, David Tennant, Geraldine Pasqual and Meredith Fairbanks.

Paper reviewed by: Caroline Peek, Allan Herbert and Kari-Lee Falconer

A tool to estimate fixed and variable header and tractor depreciation costs

Peter Tozer, Department of Agriculture, Western Australia

KEY MESSAGES

- An Excel spreadsheet calculator was developed which allows users to discern between the fixed and variable depreciation costs for tractors and harvesters.
- Traditionally, crop enterprise gross margins do not include a depreciation cost because it has been difficult to apportion between 'use' depreciation (a variable cost) and 'time' depreciation (a fixed cost).
- The calculator will provide more accurate gross margins because the variable component of the depreciation cost can now be included.

BACKGROUND

Depreciation costs are made up of two components:

- Fixed - related to the age and obsolescence of the piece of machinery; and
- Variable - due to the usage and 'wear and tear' of the piece of equipment.

Theoretically, although it is rarely done in practice, a sum of money equal to the depreciation should be set aside each year to save for the replacement of capital items.

Typically, it is assumed in most farm management decisions that all depreciation is a fixed cost. The rationale for this is that the major component of depreciation is based on the age of the capital item and that use does not significantly affect the value of the item. Calculation of the split between the fixed and variable components has been difficult to determine.

AIMS

The objective of this investigation was to develop a simple tool to estimate fixed and variable depreciation costs for tractors and combine harvesters using actual data from the Western Australian used machinery market.

METHODS

The used value, age, hours of use, brand, model number, front width, and new list price for 115 harvesters were collected. In addition, horsepower data was also collected for 68 tractors. Collation of this data enabled calculation of relationships which were then used to prepare EXCEL spreadsheets which allows easy estimation of the fixed and variable depreciation costs for either type of machine.

Basic information to estimate the depreciation costs for a harvester is shown in Table 1 below. Initial harvester cost, age, expected life, front width, speed at harvest, and harvest efficiency are easily accessible or can be approximated from existing knowledge. Harvest efficiency measures how much time the harvester is actually harvesting crop and not doing other tasks such as shifting between paddocks, unloading, refuelling, or waiting for chaser bins. A similar set of information is required for the tractor model, except front width is replaced with the width of the working gear being pulled by the tractor. Similarly, harvest efficiency is replaced by work efficiency.

Table 1. Information needed for estimation of depreciation costs (example only)

Initial cost	$350,000	Unit
Age	4	
Expected life	4	
Annual usage	500	h
Front	9	m
Speed	8	km/h
Harvest efficiency	80%	
Harvest rate	5.76	ha/hr

RESULTS

Using a harvester valued at $350,000 from the example above, the calculator estimated an age-related depreciation cost of $28,694 per year. This is a fixed cost and is deducted from the total gross margins of the farm to calculate farm operating profit.

The additional depreciation cost caused by use was $10,500 per year - equivalent in this example to $21 per hour or $3.65 per hectare. The hourly or per hectare costs can then be used in the crop enterprise gross margins, so the use-caused depreciation can be costed against the enterprise using the machine.

Table 2. Calculated fixed and variable depreciation costs for a harvester with a new value of $350,000 used for 500 hours per year and an age of 4 years old

	Annual	Hourly	Hectare	Annual rate
Age cost (fixed cost)	$28,694			8.20%
Use cost (variable cost)	$10,500	$21.00	$3.65	3.00%
Annual depreciation cost	$39,194			11.20%

A textbook straight-line depreciation calculation, using the same information as above, estimates annual depreciation to be $43,750. This is slightly higher than that estimated by the model, but the current model has the ability to break up the depreciation cost into its two components, rather than having the full cost as a fixed cost, and not allocating any depreciation or machine use costs to the relevant cropping enterprises.

At present the tool can only calculate depreciation for tractors as one class. There is no distinction between drive type or engine power due to the small data set used in the initial model building. Future advances of the model will be to develop specific models for different drive types, i.e. 4WD, 2WD, and MFWA, and for different horsepower classes.

CONCLUSION

The tool was developed from actual Western Australian machinery data during 2004. It can be used to calculate the two costs of depreciation, fixed or age-related and variable or use caused. It provides a more accurate estimate of depreciation costs than a text-book straight line method.

KEYWORDS

depreciation, cropping, economics

Paper reviewed by: Allan Herbert and Glen Riethmuller

A copy of the spreadsheet tool can be found on the Crop Updates CD and is also available from the author.

Partners in grain: 'Putting new faces in new places'

Renaye Horne, Department of Agriculture, Western Australia

KEY MESSAGES

Young people and women are often key decision makers within the farming enterprise, however many professional development opportunities do not adequately cater for this audience. Partners in Grain is putting 'new faces in new places' by facilitating professional development opportunities for grain producers with an emphasis on encouraging the participation of young people and women.

BACKGROUND

Many professional development opportunities do not adequately cater for young people and women, however, often these people have great influence over the farm business. Running events outside of school hours, not providing crèche facilities, inviting only one member of the business and simply failing to state that all members are encouraged to attend are all ways that women and young people feel unwelcome at such events and therefore can be discouraged from becoming involved in the grain industry outside of their property.

Partners in Grain (PinG) is a National GRDC funded Project initiated in 2001 to overcome these barriers to participation. Each State delivers a program that best suits the local grain industry and networks. In WA, we have focussed on delivering workshops and funding grower groups to run events such as the Family Farming Forum and Machinery Field Days.

Last year, the project was funded for a further three year term with the Department of Agriculture co-sponsoring the project within WA. The structure of the project involves a National Coordinator, then a Coordinator, Chair and Reference Group in each grain growing State.

AIM

Partners in Grain aim to build the capacity of the WA Grains Industry by actively encouraging the participation of young people and women as partners within the farm business unit through professional development opportunities.

INTO THE NEW TERM

September 2004 saw the formation of a new Reference Group within WA that will develop and deliver the program (see Contacts and Table 1). Gabrielle Coupland (CBH) was elected as Chairman and Renaye Horne (DAWA) has taken over the WA Coordinator position.

The Reference Group will continue to link groups and sponsors with complimenting objectives. Companies wishing to support WA growers and the grain industry by sponsoring professional development opportunities are invited to work with PinG, who have access to a vast, knowledge thirsty network. One of the key priorities for 2005 is to develop a formal network of interested persons who are emailed regularly with updates on PinG and upcoming professional development opportunities.

PRIORITIES FOR 2005

Priorities determined by the WA Reference Group are being acted on and a list of activities is constantly evolving. Current list of events and information on PinG can be found on the GRDC website or by contacting the State Chairman or Coordinator. Below are the top five priorities for 2005:

1. Agronomy – understanding the wheat plant.
2. Succession planning.
3. Occupational health and safety and Human resources.
4. Grain marketing.
5. Communication skills.

PinG is also coordinating the Bread Research Institute Australia's presentation of eight wheat quality workshops throughout the wheatbelt during February and March, in addition to hands on machinery workshops for women planned later in the year.

CONCLUSION

Partners in Grain is supporting the grain industry by encouraging all members of the farm business unit to become more involved through professional development opportunities. We are working towards events considering the whole farm business and running specific events targeting young people and women. If you would like to find out more about PinG events or sponsor an event, observe the GRDC website or contact the Chairman or Coordinator.

CONTACTS

Website: www.grdc.com.au (search 'Partners in Grain' and follow the links)

Gabrielle Coupland (WA Chairman)
Cooperative Bulk Handling
GPO Box L886
PERTH WA 6842
Phone: (08) 9454 0354
Fax: (08) 9454 9001
E-mail: gabriellecoupland@cbh.com.au

Renaye Horne (WA Coordinator)
Department of Agriculture WA
PO Box 110
GERALDTON WA 6530
Phone: (08) 9956 8528
Fax: (08) 9921 8016
E-mail: rhorne@agric.wa.gov.au

Table 1. Partners in Grain WA reference group members

Name	Position	Company	Location
Debbie Allen	Research Agronomist	Mingenew-Irwin Group	Mingenew
Margaret Hall	Grower		Quairading
Gary Hepworth	Head of Agribusiness	Curtin University Muresk	Northam
Julianne Hill	Development Officer	Department of Agriculture, WA	Ravensthorpe
Jill McRae	Grower	Quairading FIG	Quairading
Kirrilee Mincherton	Natural Resources Management Officer	NACC – Chapman Valley Shire	Yuna
Linda Price	Executive Officer	Barley Australia	Adelaide
Scott Uppill	Grower	Uppill and Co	Tammin
Claire Wilkinson	Stakeholder Relations Advisor	AWB	Perth

KEY WORDS

partners, grain, professional development, young, producers, women

ACKNOWLEDGMENTS

The Department of Agriculture sponsors PinG heavily which is greatly appreciated. AWB is a major sponsor of the National Project, funding the annual National Reference Group Meeting. Finally, I would like to acknowledge the previous Coordinator (Vicki McAllister), Chair (Betty Heitman) and WA Reference Group who have put so much energy into the project; leaving it in such a strong position.

Project No.: PIG 00003

Paper reviewed by: Gabrielle Coupland and Vicki McAllister

Results from the Grower Group Alliance

Tracey Gianatti, Grower Group Alliance

KEY MESSAGES

- In 2 years, the GGA has created a network of 15 grower groups, 6 research institutions and over 15 agribusiness companies. Information communicated through this network reaches over 2400 growers throughout Western Australia.
- Groups working together in the GGA network have achieved far greater outcomes than operating independently.
- Regular communication, clear definition of roles and responsibilities, and appropriate allocation of project budgets between grower group and research organisations are the three most important lessons learned from collaborative research experiences.

BACKGROUND

The Grower Group Alliance (GGA) formed in 2002 to enhance the value of agricultural research, development and extension through stronger linkages between grower groups, researchers and industry. The formation of the GGA allowed grower groups to employ a coordinator to encourage beneficial collaboration between their groups. As a result, the groups have been able to work together and reach a 'critical mass' to take action on a range of issues which they would not have been able to do individually. GGA groups are typically larger groups with a demonstrated capacity for collaborative research partnerships. Smaller, more locally focused groups are now being supported by the Local Farmer Group Network.

The Grower Group Alliance project has two key goals. These are to:

- Establish formal communication pathways between growers, researchers and the grains industry.
- Develop collaborative projects with industry based on key research issues common to Alliance members.

RESULTS

A description of the major achievements of the project from the last 2 years can be found below:

1) Regular and improved communication between Alliance members

This is the first key goal of the Alliance. It can be broken down into the following three sections:

a) Between growers and researchers/agribusiness

As a direct result of the GGA, grower groups, research agencies and agribusiness are now formalising contact via personal, written and electronic communications. This has been achieved by the GGA compiling and distributing a list of grower group contact details and their interests to researchers. To link growers with researchers, the coordinator investigates the scope of research being conducted to inform growers about any opportunities for collaboration. Researchers and growers are brought together at the GGA annual forum where introductions are made and individual groups are then left to follow up opportunities, removing the need for the coordinator to be ‘a middle man’. This encourages initiative and independence in groups and helps to expand their networks – all tangible benefits which will improve group sustainability and continue past the end of this project.

Improved communication has led to other benefits such as members of grower groups being consulted about their ideas for the future directions of research, and more specifically, what research and extension activities they would like to see conducted in their region. A change measured over the two years was that as the groups’ knowledge of research activities increased, they began to make more informed decisions about which specific researchers they could approach to conduct work in their region or invite to present findings at grower events.

b) Between grower groups

At the beginning of the project, many groups were unaware what other grower groups in the State were doing. Through its communication efforts, the GGA has broken down the barriers of distance and uncertainty between the groups. This is an ongoing activity and is achieved by the sharing of: group profiles and objectives; their newsletters, website details, and trial results booklets; and also face to face meetings of group staff and executive committee members.

The project officer visits all 15 GGA member groups at least twice each year, to pass on ideas and experiences from one group to another. A tangible result from groups working together is that two study tours with participants from many different grower groups have been conducted to interstate and overseas destinations. Two travelling technical workshops for growers on cereal disease identification and soil management were also organised by the GGA. Attendance at these workshops was unrestricted, allowing benefits from a GGA event to flow on to the wider community. Specialised training on extension methods for group staff members has been provided by the GGA. These events strengthen the operation of groups and their ability to take advantage of opportunities. Groups are now planning to explore opportunities to combine field day events and share guest presenters from interstate or overseas.

c) Between grower groups and the wider industry

Communication to the wider industry is achieved through written articles, presentations by the coordinator, and fortnightly calendar of events. Articles are written by GGA grower groups to profile their activities and extend their research results to a wider audience. This is based on the principle that growers learn best from other growers. Case studies are utilised to illustrate how research has been successfully implemented on-farm. Articles are published in the Farming Ahead and Australian Grain magazines, GRIST, grower group newsletters, rural media and GRDC Ground Cover.

In 2003, the GGA initiated a calendar of events to reduce the clashes between grower group and researcher events. This is coordinated by the project officer and emailed directly to 240 people fortnightly. The calendar is then forwarded on to grower group members and employees of large organisations around WA.

2) Development of collaborative projects

The second goal of the GGA is to increase the number of collaborative projects between growers, researchers and industry. The first hurdle to overcome was that many prospective partners were unsure of the best way to engage grower groups. In response, the GGA defined three broad categories where grower groups can be involved in research and the expectations at each level. Distribution of grower group profiles also helped researchers to understand potential partners.

A key event to catalyse new projects was the establishment of the annual GGA 'Industry Research' forum. It allows researchers and growers to meet, develop personal relationships, and share their research priorities. As a result of the 2003 forum, four collaborative projects were successfully funded. An example of a project initiated and organised by the GGA was a successful submission by five grower groups and the Department of Agriculture to the National Landcare Program which will enhance the ability of grower groups to implement sustainable agricultural practices. The 3 year project secured a budget in excess of $500,000. In another new initiative, the GGA has offered two $2000 scholarships for UWA fourth year students to undertake a collaborative project with a grower group. The first students begin in 2005.

3) Increase in number of grower groups involved

At the beginning of the project, only six grower groups were involved. Within three months, three additional groups had approached the GGA to become involved. After two years, the GGA now consists of a network of fifteen grower groups. A survey of GGA members found the main benefits of membership include:

- increased information transfer between groups and researchers;
- improved profile and credibility of the GGA and its members (in WA, interstate and overseas);
- gathering together for critical mass, leading to development of collaborative projects;
- tailored training and development for group members and staff;
- calendar of events: this increases the industry's awareness of grower group activities.

CONCLUSIONS

During the next three year phase of the project, the GGA aims to continue building strength in grower groups and developing collaborative projects with research providers. Stronger grower groups will provide better services to their members thereby allowing them to make the best possible decisions for their farm business.

KEY WORDS

grower groups, communication, collaborative projects

ACKNOWLEDGMENTS

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Project No.: MIG00002

Paper reviewed by: Rick Llewellyn

Local Farmer Group Network – farming systems research opportunities through local groups

Paul Carmody, Local Farmer Group Network

KEY MESSAGES

- A new support network now exists to facilitate collaboration with small, locally-focused farmer groups.
- Opportunities exist for researchers and agribusiness to do farming system research with these groups.

THE LOCAL FARMER GROUP NETWORK

What is it?

Throughout the wheatbelt over the past few years the large number of locally focused, small grower groups have been operating without a support network. The Local Farmer Group Network (LFGN) is a new initiative by the GRDC and is hosted by the Faculty of Natural and Agricultural Sciences, University of Western Australia. The project is managed by a committee made up of grower group representatives, UWA, agribusiness and Department of Agriculture. The primary objective of the project is to increase the adoption new technology through a network of support for local farmer groups.

There are over 20 active local groups throughout the wheatbelt and potentially another 40 less active local farmer groups. These local groups have a wide range of activities and interests but they all tend to focus on raising the productivity and profitability of their group members. Some groups have community orientated outcomes while others have catchment management focus but all groups within the network deal with grain production.

AIMS

To support small Western Australian locally focused grower groups in achieving their objectives.

To improve the adoption of new technology by local farmer groups and better integrate it into local farming system without unnecessary duplication of this research across the network.

Who is in the Local Farmer Group Network?

The list below includes some of the active groups registered within the Local Farmer Group Network and their current chairperson or contact.

Group Chairperson	Group name	Location
David Forrester	Casuarinas TopCrop Group	Geraldton East
Harvey Morrell	Brookton LCDC	Brookton
Keith Wilson	Freebairn FIG Group	Kulin
Nils Blumann	Gibson Lupin Group	Esperance North
Ron Longbottom	Grass Patch TopCrop	Esperance North
James Ryan	Jerdacuttup TopCrop	Raventhorpe East
David Leake	Kellerberrin Farm Improvement Group	Kellerberrin North
Kim Maddock	Ninghan Farm Focus Group	Mukinbudin
Andrew Longmire	North Mallee Farm Improvement Group	Salmon Gums
Gordon Wilson	Northern Agri Group	Northampton East
Jenny Chambers	Ravensthorpe Agricultural Initiative Network	Raventhorpe
Luke Caelii	West River Farm Productivity Group	Jerramungup East
Peter Pascoe	Woolocutty Group	Narembeen East
Andrew Williamson	Yuna Farm Improvement Group	Yuna

There are over 40 local farmer groups throughout the Western Australian grainbelt not including the large groups which are a part of the Grower Group Alliance (GGA). The LFGN and GGA are both based at UWA and work in partnership to support WA grower groups.

What do we do?

Local Farmer Group Network plans to create a learning environment for farmers by encouraging the exchange of ideas and solutions and help accelerate the adoption of new technology. Local groups will be able to utilise the services of the network team to help them source technical information, decision aids, training courses, researcher, industry collaborators or other grower groups with similar issues.

Local farmer groups are being linked through the network which will increase information sharing between groups and promote cross fertilisation and improvement of ideas. Linkages to researchers and industry specialists will allow direct access for groups and individuals to evaluate technical information and research outcomes while providing important feedback on the issues and challenges.

For growers

The benefits for growers and their groups will be:

- assistance in identifying their goals and requirements;
- improved access to relevant research projects and product development;
- identify funding opportunities and collaboration;
- sharing of trials results and demonstration ideas with groups across the network;
- increase their access to workshops and seminars.

A network system to establish more formal communication between grower groups will help minimise the problem of growers ‘re-inventing the wheel’ with regards to trial design, coordinating workshops and applying for funding opportunities, etc. This project will also help deliver specific technical information to growers through learning tools which update their skills and knowledge.

For potential collaborators

The Local Farmer Group Network offers collaborators in research and agribusiness better access to small growers groups for input of ideas at the local level. The smaller local groups can provide the intimacy and focus often required by research into things as complex as farming systems. They also offer an effective way to obtain feedback on the relevance of new technology in todays farming systems.

LFGN can provide agribusiness and researchers with a wide variety of opportunities:

- Present group profiles, resources and needs to help identify potential partnership in research.
- Access to a diverse array of environments and systems for research.
- Identify potential funding partners (grower groups) for projects.
- Vehicle for the evaluation of new technology or decision making tools.
- Add value and increase the impact of research and extension activities.

As a centrally based project team it will assist researchers get in touch with grower groups and provide a formal communication channel between them for better integration of research ideas.

CONCLUSION

There are opportunties for agribusiness, advisors and researchers to gain from the benefits of working with local grower groups. The LFGN exists to support these partnerships. For more information visit http://www.grdc.com.au/growers/gg/lfgn.htm.

KEY WORDS

grower groups, networks, integrated farming systems research, local groups, TopCrop

ACKNOWLEDGMENTS

Tracey Gianatti, Grower Group Alliance; LFGN Management Committee; GRDC

Project No.: UWA00082

Paper reviewed by: Rick Llewellyn, UWA

Changing rainfall patterns in the grainbelt

Ian Foster, Department of Agriculture, Western Australia

KEY MESSAGES

Growing season rainfall over south western WA has changed significantly over the past three decades, having shifted to a generally drier regime since the mid-1970s. This will challenge our assumptions of average rainfall patterns. Early season rainfall (May to July) has declined, but there has been little trend in spring rainfall. Wet years are much less frequent, compared with the previous three decades. Rainfall contours have generally shifted towards the West Coast, and the estimated incidence of waterlogging has decreased. In contrast, summer rainfall has tended to increase, especially in eastern agricultural areas.

AIMS

Climate variability and climate change are significant issues for Western Australia in terms of economic development, water supply and social and environmental impact. Growing season rainfall over the past three decades has been significantly drier than for most of the 20th Century. This paper illustrates some of the main features of these changes.

METHOD

The Bureau of Meteorology provided grided rainfall data, while historical rainfall for specific locations was extracted from the Australian Rainman database. Mean seasonal rainfall for the years 1976 to 2003 were compared with means generated for the years 1925 to 1975.

The number of days of waterlogging for a shallow duplex soil (depths 100 and 200 mm) was simulated at individual locations using a simple two-layer water balance model. Dates of historical sowing opportunities were estimated using PYCAL (Potential Yield Calculator).

RESULTS

- Most of the decline has occurred early in the growing season (i.e. May-July), with little trend in spring rainfall (see example for Corrigin in Figure 1). Rainfall over January to March has generally increased, especially in eastern agricultural areas.
- Decreases in average May-July rainfall have been up to 20% in some locations, with fewer very wet years (i.e. May-July rainfall in the wettest 20% of all years). In contrast, South Coast growing season rainfall has remained generally steady.
- Spatial changes in growing season rainfall contours are shown in Figure 2. There has been a shift in mean contours towards the West Coast over the past three decades, especially for the high rainfall zones.
- The average number of days of estimated waterlogging in susceptible locations has declined by up to 30%.
- The average date of the first sowing opportunity since the 1970s has shifted later by 3 to 6 days in some central, southern and eastern locations. In other regions, the timing of sowing opportunities has not changed significantly.

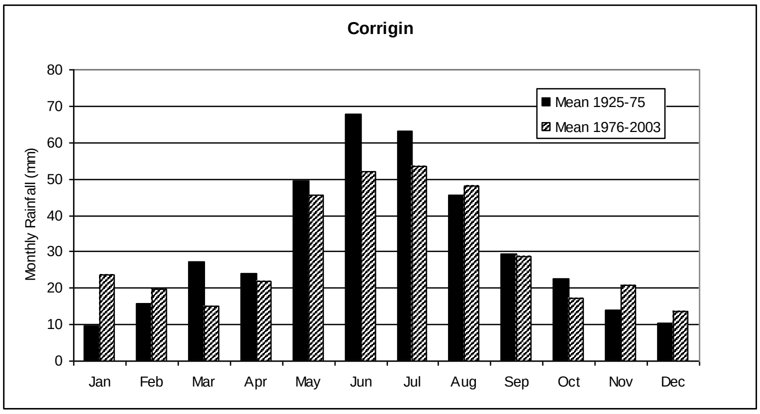


Figure 1. **Average monthly rainfall for Corrigin, for 1925-75 (full columns), and for 1976-2003 (shaded)**

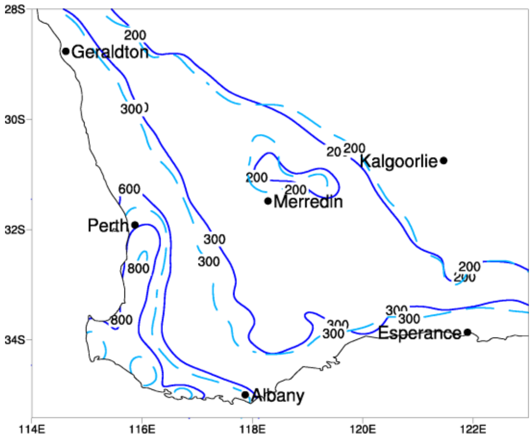


Figure 2. **Rainfall contours for May-October for two periods: 1925-75 (solid) and 1976-2003 (dashed). Source: Bureau of Meteorology Research Centre.**

CONCLUSION

Seasonal rainfall averages and spatial patterns over the past three decades are significantly different from previous experience in many parts of the Grainbelt. The base rainfall assumptions used for planning purposes must be reviewed to accommodate the new patterns, especially for situations that are sensitive to heavy seasonal rainfall.

Despite this, the overall seasonal distribution of rainfall and timing of sowing opportunities remains relatively unchanged.

The decrease in incidence of waterlogging estimated for susceptible soils has probably contributed to generally improved conditions for cropping in medium to high rainfall zones.

KEY WORDS

rainfall trends

ACKNOWLEDGMENTS

Pandora Hope (BMRC Melbourne) for the rainfall contours; Greg Hamilton for the waterlogging rules. This paper has also drawn on the work of the Indian Ocean Climate Initiative.

Paper reviewed by: Imma Farre and Miles Dracup

Vulnerability of broadscale agriculture to the impacts of climate change

Michele John, CSIRO (formerly Department of Agriculture) and **Ross George**, Department of Agriculture, Western Australia

KEY MESSAGES

- Future climate change projections, especially rainfall changes, are uncertain. Nevertheless long term planning needs to consider the vulnerability of agriculture under a variable but trending (warming and drying) climate scenario.
- The eastern wheatbelt, typified by the Merredin area, is highly vulnerable to long term climate change. Farm profits, even on well managed farms, declined by up to 75% under the worst case scenario. Socio-economic impacts could thus be severe for these areas.
- Technological solutions may not be enough as they are likely to be cancelled out by the expected continuing decline in the terms of trade for agriculture. With current knowledge, the tactical options for farmers to mitigate climate change impacts appear limited.
- The probability of good years is projected to decline, on average, from 1 in 3.4 years to 1 in 5.4 years. This would have a significant impact on the viability of most farms, which rely on good seasons to repay farm debt and finance farm expansion/capital purchases.
- The projected climate trends reinforce the need for seasonal predictive tools and for increasing the awareness and skill of farmers in using these. See the Climate Risks and Opportunities Project.

AIMS

To assess the vulnerability of farm businesses in the eastern wheatbelt to the projected impacts of climate change.

METHOD

Climate change projections for the south west of Western Australia to the mid-21st Century have been converted to series of characteristic season types for the eastern wheatbelt (Merredin district) of Western Australia. Their probabilities of occurrence are different for the projected future climate, compared with current conditions.

These projected season type probabilities have been included in the MUDAS model, a whole farm bio-economic model to compare the current profits and farm management with those under the projected climate change scenarios.

RESULTS

The modelling showed profitability declines of up to 75%, with a decline in farm tactical management activities. Whilst enterprise mix across the farm did not change significantly other than a slight movement towards pasture-livestock management, the projected doubling of the probability of dry years results in the distribution of good years declining, on average, from 1 in 3.4 years to 1 in 5.4 years. This projected decline in the occurrence of good seasons would have a significant impact on the viability of most farms, which rely on good seasons to repay farm debt and finance farm expansion/capital purchases.

Factors that reduce profitability under climate change conditions include the declining profitability from sheep enterprises with decreasing pasture yields, declining sheep carrying capacity, decreases in sheep selling activities, and substantial increases in lupin feeding.

If a 12% productivity improvement from the adoption of newly developing drought tolerant wheat species is included in the above analysis, the profitability of the optimum farming system under climate

change recovers, but not completely. However, if the long term trend of the declining terms of trade for wheat is also included, the analysis predicts that the technology gains are negated.

Western Australia experienced its first Exceptional Circumstance declarations in 2000, 2001 and 2002, and these have included the region modelled in this study. These events cost $44 million in direct government support up until the end of January 2003. The total value of lost production (years 2000, 2001, 2002) was assessed as being $525.5 million. With an increased risk of drought years predicted, these figures are an indication of recurring future costs if long term policy and planning does not consider the impacts of climate change on agricultural businesses.

CONCLUSION

The analysis indicates agriculture is vulnerable to climate change. The climate change scenarios modelled are 'worst case' scenarios, but have been applied to a farm that would normally be considered in the top 20% of performers in the area. Therefore, the negative financial implication of climate change for the other 80% of farms is even more significant.

Uncertainty of rainfall projections is a major issue clouding the model predictions and they must therefore be treated with caution. Responses/adaptation needs to occur in a risk management framework. To support this, future research needs to determine the critical thresholds, at which current systems will be unable to cope, thereby causing major economic and social consequences for regional communities.

Improving the prediction of seasonal conditions is highly relevant to tactical decision-making, reflecting the relatively short term planning horizons of farm businesses. Long term climate change is, however, a reality and we will be required to adapt even if there is concerted global action to reduce greenhouse gas emissions. Improved and widespread understanding of future challenges will generate opportunities and enable industry planning for a less costly and disruptive transition.

KEY WORDS

climate change, vulnerability, dryland cropping

ACKNOWLEDGMENTS

This research was carried out by Michele John as part of her PhD studies at UWA and was funded by the Department of Agriculture WA.

Paper reviewed by: Ian Foster

Impacts of climate change on wheat yield at Merredin

Imma Farré and **Ian Foster**, Department of Agriculture, Western Australia

KEY MESSAGES

- Over the coming decades southern Western Australia (WA) is likely to become warmer and drier.
- Simulated yields are very sensitive to rainfall distribution.
- Although some compensation exists for higher CO_2, the simulations for Merredin on a clay soil show future yields lower than current yields.

AIMS

Climate change is already occurring. Climate change projections for the mid 21st century for southern WA indicate an increase in temperatures, a decrease in rainfall and higher CO_2 concentrations. These changes could have adverse impacts on some agricultural systems, but they may also offer new opportunities in areas where the risk of frost damage or waterlogging may be reduced. We need to know the impacts of climate change on the cropping industry in WA in order to plan adaptation strategies. To assess these impacts, current and future climate simulated by climate models can be coupled to crop simulation models. The aim of this paper is to study the impact of climate change on wheat production at Merredin on a clay soil, a key location in the low rainfall region of WA.

METHOD

The APSIM-Wheat model was used with current and future climate data to simulate grain yield. The wheat model was run with four sets of climate data: observed climate for 1970-2000, current simulated climate for 1970-2000, future simulated climate for 2035-2065 with current level of CO_2 (350 ppm) and future climate with expected CO_2 level in the mid 21st century (440 ppm). Simulated current and future climate data were obtained from the CSIRO MK3 model. Observed climate data came from the Bureau of Meteorology station in Merredin.

Simulations were performed for Merredin, in the low rainfall region of WA. A clay soil with 109 mm plant available soil water was chosen. Simulations were performed for periods of 30 years assuming the soil was dry at 1 January each year. Sowing time was controlled by a sowing rule. Every year sowing occurred in the first sowing opportunity between 20 April and 31 July. Spear (long maturing) was sown if sowing occurred before 5 June and Kulin (short maturing) was sown after that date. Current management in the area were selected for the simulations.

RESULTS

Simulated current climate had maximum and minimum temperatures in agreement with observed climate (data not shown). Total annual rainfall was well simulated, but rainfall tended to be underestimated in autumn and overestimated in spring (Figure 1). Simulated future annual rainfall was 10% lower than current.

In Merredin, on a clay soil, yields for simulated current climate were lower than yields for observed climate (Figure 2). The difference was due to the bias in rainfall distribution, which caused sowing to occur later. The decrease in yield caused by delayed sowing was due to a reduction in growth duration and increased chance of a more severe water deficit during grain filling.

Yields for future climate with a CO_2 level of 350 ppm (current atmospheric concentration) were lower than yields for simulated current climate (Figure 2). The decrease was due to lower rainfall and higher temperatures, which caused shorter growth duration and more water deficit.

Yields for future climate with a CO_2 level of 440 ppm (expected concentration in the mid 21st century) were higher than with the CO_2 level of 350 ppm (Figure 2). Even though some compensation occurred for high CO_2 levels, future yields (average 1.6 t/ha) were lower than current yields (average 1.8 t/ha).

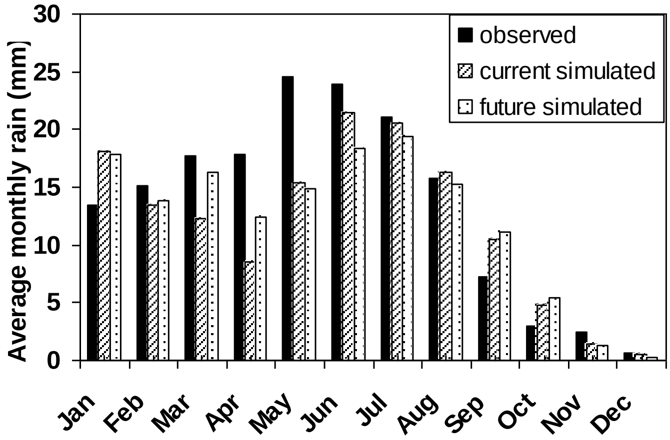


Figure 1. **Average monthly rainfall at Merredin for observed, current simulated and future simulated climate. Simulated climate obtained from the CSIRO MK3 model.**

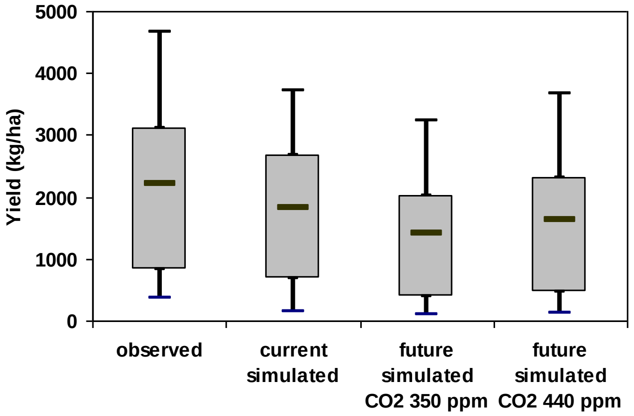


Figure 2. **Simulated yields for Merredin on a clay soil using the APSIM-Wheat model with observed, current simulated and future simulated climate, and future simulated climate with high CO_2 level. Whiskers show the 10% and 90% percentiles. Solid bars show the 25% and 75% percentiles. Line within the bar shows the average.**

CONCLUSION

Average future yields at Merredin on a clay soil will be lower than current yields. Some compensation from higher CO_2 will occur.

Simulation of future wheat yields is sensitive to the rainfall distribution. The actual bias in the simulation of rainfall poses a limitation to the studies of the impact of climate change using climate models. However, quick progress is occurring in the improvement of climate models.

Simulation analysis using crop simulation models with simulated climate data can be used to evaluate the risks of climate change on crop production.

Adaptation will be needed to overcome some of the projected adverse impacts of climate change.

KEY WORDS

climate model, crop model

ACKNOWLEDGMENTS

This work is funded by the Grains Research and Development Corporation

Project No.: DAW00088

Paper reviewed by: Geraldine Pasqual and David Tennant

Climate change, land use suitability and water security

Ian Kininmonth, Dennis van Gool and **Neil Coles**, Department of Agriculture, Western Australia

KEY MESSAGES

Knowledge about climate is a major factor affecting the adaptability of farmers and regions to change. The climate change and land use suitability project will indicate the likely impacts on several major crops for the next 5, 20 and 50 year periods if the south west becomes drier, and rainfall and temperature patterns change as current climate models suggest.

In addition to land use suitability and industry adaptation the availability of reliable water supplies in a drying climate will take on increasing importance. Land use change will invariably be reflected in changes in water demand whether that be for crop, domestic or livestock requirements. In areas with decreasing rainfall an increasing percentage of the landscape may need to be adapted for water harvesting, capture and storage, with a need to develop re-distribution systems.

The results of these resource assessments are expected to provide an important resource to assist industry, natural resource management and regional planning.

AIMS

The twelve month land capability and water supply projects have the main aim of providing information on implications of possible climate change on land use (plant) suitability and water supply reliability to assist regional and industry planning. The geographic focus is initially the south coast and parts of the dryland agricultural areas of south-western Australia.

Plant species which are the focus of the land use project are barley, noodle wheat, lupins, canola, faba beans, field peas, chickpeas, bluegums, maritime pine. A database of information for the different plant species will be created which can be used for a range of analytical and planning applications.

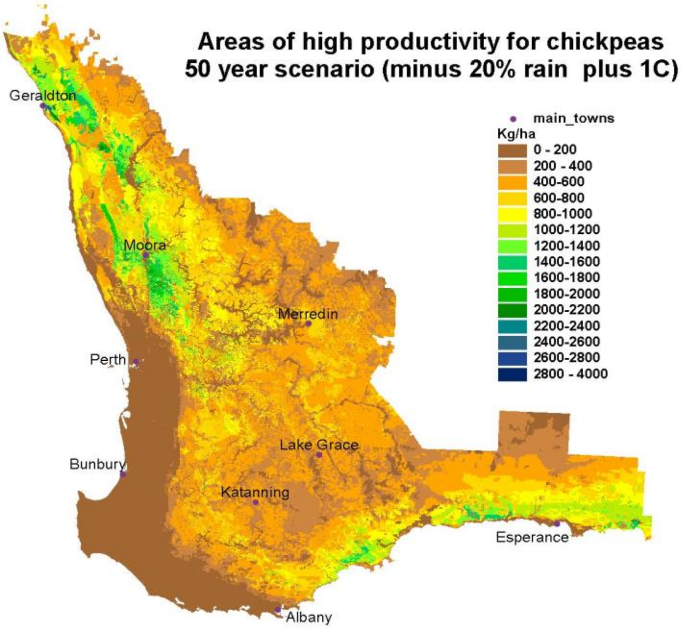
METHOD

Land use capability tables are created for specific plant species in consultation with industry experts. This information is then intersected with information in the Department of Agriculture's soils database as well as climate information to generate maps showing potential land use suitability and yields (or growth rates). Further consultation and 'ground-truthing' is undertaken with industry experts to generate the final maps (see Figure 1).

Water demand scenarios will be modelled to determine the impact of seasonal shifts and changes in rainfall intensity and duration in the dryland agricultural areas. These shifts will be reflected in modified design criteria for the development of reliable on-farm water supplies.

RESULTS

An example of mapping chickpea suitability has been undertaken. This indicates that under a 50 year scenario assuming a 20% reduction in rainfall and 1 degree Celcius increase in average temperature, that the area suitable for chickpeas could increase significantly, in particular to the west (see Figure 1).



Figureo 1. Areas of high productivity for chickpeas based on a 50 year scenario (minus 20% rainfall plus 1 degree Celsius).

Preliminary modelling suggests that significant areas of improved catchments will need to be added to the majority of dams in the 400-600 mm rainfall zone, and the average dam size will need to increase by as much as 25%. Standard design models suggest that an additional 1 ha of improved catchment is required for each 1000 m^3 of storage above 1500 m^3. This is similar to the design criteria employed in the drier areas of the eastern wheatbelt.

CONCLUSION

The information generated through these projects is expected to provide a valuable resource for industry and regional planning. Land use suitability information can highlight needs related to research (e.g. into new varieties and cultivars), biosecurity preparedness (e.g. pest and disease risk), extension (e.g. information packs on seasonal risks and opportunities) and infrastructure. In water security, the level of water availability and reliability of supply will allow industry to determine the sustainability of current or changed land management practices or industry focus. The land capability database and modified water supply design criteria are valuable resources, but it should be recognised that many other factors affect land use and that climate forecasting on a seasonal let alone long term basis has a high degree of uncertainty and should be used with a significant degree of caution.

KEY WORDS

land use suitability, climate forecasting, adaptability, reliability, water, demand, design criteria

ACKNOWLEDGEMENTS

Peter White from the Department of Agriculture's pulse program who collaborated with production of the chickpea suitability map.

Nitrous oxide emissions from cropping systems

Bill Porter, Department of Agriculture, Western Australia and **Louise Barton**, University of Western Australia

KEY MESSAGES

Nitrous oxide (N_2O) is a greenhouse gas that can be emitted from agricultural soils. N_2O is of particular concern as it has 310 times more global warming potential than carbon dioxide (CO_2) and contributes to the destruction of the ozone layer.

Overseas research suggests that 1.25% of all inorganic nitrogen fertiliser plus 0.25 kg N/ha/yr is emitted as N_2O from cropped soils. This value has been used to calculate Australia's national greenhouse gas inventory. However, no-one has determined if this value is applicable to WA grain production systems.

The Department of Agriculture has commenced a new research project that will measure N_2O emissions from WA cropping systems.

GREENHOUSE EMISSIONS FROM WESTERN AUSTRALIAN AGRICULTURE

Agriculture contributes approximately 27% of Western Australia's total net greenhouse emissions (Figure 1). Carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) are the main greenhouse gases produced from WA agriculture.

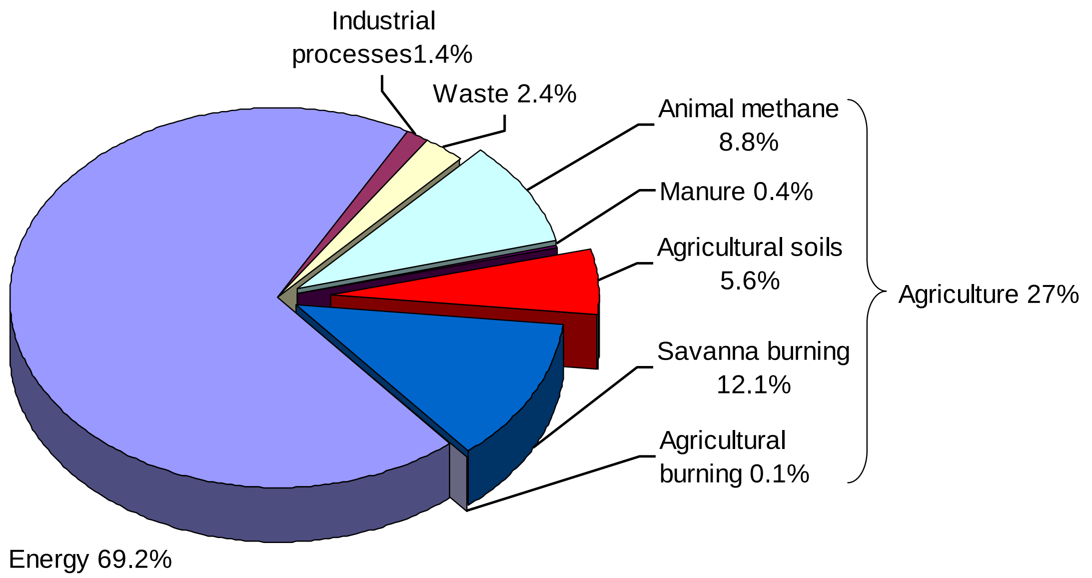


Figure 1. Sectoral contributions to Western Australia's greenhouse gas emissions profile in 2002. The chart excludes land use change and forestry which consumed (sequestered) greenhouse gases equivalent to about 3.6% of WA's total emissions in 2002. (Source: Australian Greenhouse Office and WA Greenhouse Task Force.)

Nitrous oxide is a powerful greenhouse gas with a global warming potential of 310 times that of carbon dioxide. Furthermore, N_2O has the dubious distinction of contributing to global warming and to the destruction of the ozone layer. Approximately 6% of WA's greenhouse gases come from agricultural soils, with N_2O produced from the grains industry being a major contributor to this. This estimate is based on overseas research that suggests that 1.25% of all inorganic nitrogen fertiliser (plus 0.25 kg

N/ha/yr) is emitted as N_2O from cropped soils. However, no-one has determined if this value is applicable to WA grain production systems. New research commencing in 2005 will obtain the first measurements N_2O emissions from cropped soils in WA.

NITROUS OXIDE PRODUCTION IN SOIL

Nitrous oxide is produced in soils primarily by soil microbes. The two main soil biological pathways that produce N_2O are nitrification and denitrification (Figure 2). Nitrifying microbes convert soil ammonium to nitrate under aerobic soil conditions, with incomplete conversion resulting in the formation of N_2O. Because the nitrification process relies on a good availability of oxygen it is an important source of N_2O in well drained and aerated soils. Denitrifiers reduce nitrate to nitrogen gas, generally in anaerobic soil, when nitrate, available carbon and temperature are not limiting. During denitrification the N_2O produced can be further reduced to N_2, but usually a proportion escapes to the atmosphere. In wet or more compact soils, where soils are anaerobic, conditions are more suitable for denitrification than nitrification.

Nitrous oxide production from soils will vary depending upon on a number of factors including soil water content, availability of ammonium and nitrate, temperature, organic carbon levels, and soil pH. These will in turn be influenced by farm management practices such as nitrogen fertiliser management, crop rotations and soil tillage practices.

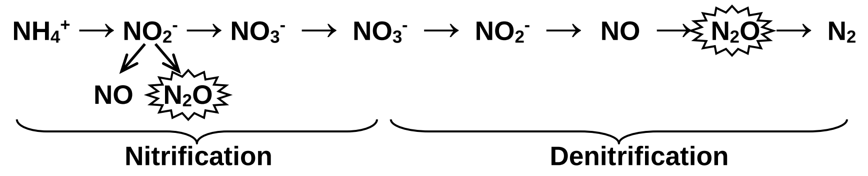


Figure 2. Nitrous oxide is produced from soils by nitrification (aerobic soil conditions) and denitrification (in mildly anaerobic soil conditions).

POTENTIAL FOR MANAGING N_2O EMISSIONS FROM GRAIN PRODUCTION

In Australia, almost 90% of the increase in N_2O emissions (from 1990-1999) has been attributed to an increase in the rate of N fertiliser use. The main strategies proposed to minimise N_2O emissions from agricultural soils are to improve the efficiency of nitrogen fertiliser use (for example, better matching nitrogen fertiliser applications to crop requirements) and to minimise the incidence of waterlogging.

CONCLUSION

In helping the world address global warming, the WA grain industry may be able to contribute by improving the efficiency of nitrogen use in its farming systems and so minimise N_2O emissions. New research led by the Department of Agriculture will measure N_2O emissions from WA cropping systems for the first time. Understanding the contribution of WA grain production systems to N_2O emissions will assist refine Australia's Greenhouse Inventory, plus assist with the development of practical management strategies for minimising emissions from these systems.

KEY WORDS

greenhouse gas, global warming, nitrous oxide, grain production, environment

Project No.: DAWA, GRDC and Australian Greenhouse Office Project DAW00103

Paper reviewed by: Dr Richard Eckard, Program Manager, CRC for Greenhouse Accounting

The potential of greenhouse sinks to underwrite improved land management in Western Australia

Richard Harper and **Peter Ritson**, CRC for Greenhouse Accounting and Forest Products Commission, **Tony Beck**, Tony Beck Consulting Services, **Chris Mitchell** and **Michael Hill**, CRC for Greenhouse Accounting

KEY MESSAGES

- Farmland revegetation for salinity control and biodiversity enhancement may be subsidised by carbon investors.
- Some early investment in carbon sinks is occurring in Western Australia.
- There is considerable certainty about the amount of carbon that can be sequestered in trees; less certainty about the amount of carbon that can be sequestered as a result of rangeland destocking, saltbush establishment or changes in tillage practice.

AIMS

There are large projected increases in salinisation, decreases in water quality and losses of biodiversity in agricultural areas across Australia. Increased concentrations of greenhouse gases have been linked to global warming. The international response to this warming, the United Nations Framework Convention on Climate Change and its Kyoto Protocol, include provisions that enable greenhouse sinks, or the sequestration of carbon in soils and vegetation to be used by Parties as a strategy to fulfil their obligations. The Kyoto Protocol also allows for trading in emission reductions, and this opens the possibility that investment in carbon sinks may help underwrite broader natural resource management objectives. Consequently, the Western Australian Government has passed the *Carbon Rights Act 2003* with this establishing a statutory basis for the ownership and protection of Carbon Rights, in order to facilitate trading. Although the Kyoto Protocol has not been ratified by Australia there is still considerable interest in carbon mitigation in sinks as a means of meeting corporate and national emissions targets.

We examined the possibilities for improved land management in Western Australia arising from the development of carbon sinks. This study considered: (a) the likelihood of a carbon market developing and the likely depth of that market as a result of current national and international policies; (b) the data available to provide estimates on different types of sinks; and (c) the likely benefits of wide-scale sink investment. The study was designed to quantify an upper limit to sink potential.

It was estimated that the total amount of carbon that could be sequestered by revegetating 16.8 Mha of cleared farmland was 2.2 billion tonnes CO_2-e, and 3.3 billion tonnes CO_2-e by destocking 94.8 Mha of Western Australian rangelands. It was considered that there were insufficient data to produce estimates of sequestration following changes in tillage practice in cropping systems or the revegetation of already salinised land with species such as saltbush. We conclude that carbon sinks are only likely to become profitable as a broad-scale stand-alone enterprise when carbon prices reach A$15/t CO_2-e, and then only in certain areas. However, below this price their value can be significant as an adjunct to reforestation schemes that are aimed at providing other products (wood, pulp, bioenergy) and land and water conservation benefits. Irrespective of this, carbon sinks provide an opportunity to both sequester carbon in a least-cost fashion and improve soil and watershed management.

Details of the full report are:

Harper, R.J., Beck, A.C., Barrett, D.J., Hill, M., Ritson, P., Tomlinson, R., Mitchell, C., Mann, S.S. (2003). 'Opportunities for the Western Australian land management sector arising from greenhouse gas abatement. Report for the Western Australian Greenhouse Taskforce, brief. AGR131Q-02/03.' Cooperative Research Centre for Greenhouse Accounting, Canberra. http://agspsrv38.agric.wa.gov.au/pls/portal30/docs/FOLDER/IKMP/LWE/EM/crcgreenhouse.pdf.

KEY WORDS

greenhouse, carbon dioxide, revegetation

ACKNOWLEDGMENTS

We thank Rick Tomlinson of CALM for undertaking the GIS analysis. We acknowledge funding for the scoping study from the Western Australian Greenhouse Sinks Taskforce (Project Brief AGR131Q-02/03) and thank Ross George, Richard McKellar and Anne Bennett for valuable discussion. The views in this paper are those of the Cooperative Research Centre for Greenhouse Accounting.

Paper reviewed by: Anne Bennett, Department of Premier and Cabinet

Removing uncertainty from greenhouse emissions

Fiona Barker-Reid, Will Gates, Ken Wilson and **Rob Baigent**, Department of Primary Industries - Victoria and CRC for Greenhouse Accounting (CRCGA), and **Ian Galbally, Mick Meyer** and **Ian Weeks**, CSIRO Atmospheric Research and CRCGA

KEY MESSAGES

Nitrous oxide (N_2O) is a potent greenhouse gas (GHG) responsible for 20% of Australia's agricultural emissions. Australia's GHG emissions are currently estimated using research from Europe and North America despite differences in soil, climate, cropping systems and practices that may affect GHG emission rates. We quantified soil N_2O emissions from dryland wheat (Rutherglen, Victoria) to assess the relevance of Northern Hemisphere data to the Australian environment, to evaluate environmental and management factors contributing to N_2O losses and to develop practical mitigation strategies. The results presented here show that:

- soil water (rainfall) and mineralised soil nitrogen (N) are the key factors affecting soil N_2O losses;
- annual soil N_2O losses were between 0.13 and 0.20 kg N ha^{-1} yr^{-1};
- soil N_2O losses were greatest in June 2004, within one to three days of rain events;
- N mineralisation rates and mineral N levels correlated strongly with N_2O emissions in June; and
- only minor soil N_2O emissions were associated with post-emergence N fertiliser applications.

AIMS

- To develop robust methods and expertise to measure N_2O emissions in a cropping situation; and
- To establish baseline data concerning N_2O emissions from dryland wheat.

METHOD

Field plots were sown to wheat within a long-term tillage experiment in North-East Victoria on fine sandy loam (surface) soils where the average long-term (winter dominant) rainfall is 590 mm. The effects of three management practices on soil N_2O emissions were examined:

1. Conventional cultivation, stubble burned, no N fertiliser applied (CC-N).
2. Conventional cultivation, stubble burned, N fertiliser applied (CC+N) as urea; and
3. Direct drilled, stubble retained, N fertiliser applied (DD+N) as urea.

Granulated urea was split applied post emergence at the 1st node and boot stages. Soil N_2O emissions were collected continuously over two- and three-day intervals using automated gas collection chambers designed by CSIRO. Gas samples were analysed using a Varian 3800 Gas Chromatograph equipped with electron capture detector. Quality emission measurements commenced in March 2004. Continual soil water, soil temperature, and air temperature data, associated with each chamber, were also collected using 4 data loggers.

RESULTS

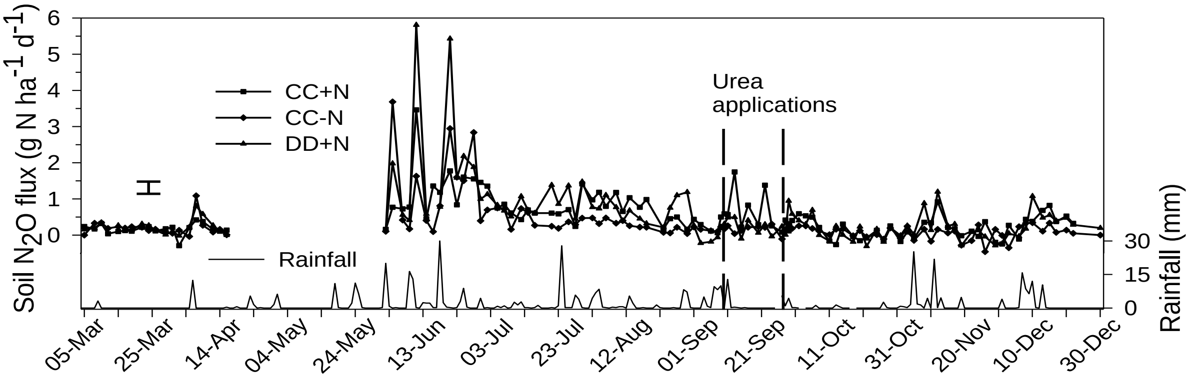


Figure 1. Daily soil N_2O emissions from dryland wheat (Rutherglen, Victoria) averaged for each treatment. Mid-April–May break in data due to burning, cultivation and sowing of experimental plots. The error bar represents 2 standard deviations (0.4 g N ha^{-1} d^{-1}) calculated from non-emitting dates.

Table 1. Correlation coefficients (r) for the quantity of soil mineral N (ammonium, nitrate and total) determined monthly from January to June (2004) with cumulative soil N_2O losses from dryland wheat (Rutherglen, Victoria) in June (2004)

	Mineral N		
	NH_4	**NO_3**	**Total**
January	0.951	0.853	0.864
February	0.798	0.617	0.650
March	No Cor	0.724	0.739
April	0.999	0.896	0.911
June	No Cor	0.975	0.980

Our research has found that:

- Since March 2004, soil N_2O emissions ranged between 0 and 5.8 (± 0.4) g N ha^{-1} d^{-1}.
- Soil N_2O emissions observed in early March were within detection limits (less than 2 standard deviations from zero), except for a minor loss corresponding to a rainfall event.
- Losses of soil N_2O having greatest magnitude were observed in June within one to three days following a rainfall event (Figure 1).
- Soil N_2O emissions generally correlated strongly with both the quantity of soil mineral N (Table 1) present prior to sowing and N mineralisation rates, indicating that N mineralised from soil organic matter during fallow formed a significant part of the N pool available for (de)nitrification reactions and lost as N_2O.
- Measured soil N_2O emissions declined from July to October 2004, corresponding to increased crop growth (emergence 31 May 2004), cooler daytime and soil temperatures and depletion of soil mineral N pools.
- Minor soil N_2O emissions corresponded with the split urea application in September 2004, due to application to wet soil and efficient crop utilisation of fertiliser; and
- Annual soil N_2O losses were 0.126 (CC-N), 0.163 (CC+N) and 0.196 (DD+N) kg N ha^{-1} yr^{-1}.

CONCLUSION

These preliminary results demonstrate that the major drivers of soil N_2O emissions are rainfall and soil mineral N content prior to sowing. Soil N_2O losses of greatest magnitude were observed during June rainfall when soil temperatures were warm, soil water was adequate and sufficient mineral N remained for microbial (de)nitrification reactions. Only minor soil N_2O emissions were associated with the split urea application to wet soil, most likely due to efficient fertiliser use by the crop. These results indicate that fertiliser emission rates used in the national GHG inventory may over-estimate fertiliser N loss due to (de)nitrification when applied post-emergence. Mineral N accumulated in the soil due to mineralisation of organic matter during the fallow months, however, may be an under-estimated source of N_2O emissions.

Based on our results and recent literature, useful strategies designed to reduce soil N_2O emissions from Australian agricultural soils may be best achieved through management practices that improve the use of available soil mineral N and efficiency of N fertiliser applications. Our results will enable evaluation of emission factors (e.g. for fertiliser) currently used by the National Greenhouse Gas Inventory (NGGI) for estimating soil N_2O emissions from agriculture throughout Australia.

KEY WORDS

greenhouse gases, nitrous oxide, wheat, soil mineral N, split applied urea

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NB: There is an extended version of this paper on the Crop Update 2004 CD.

Greenhouse in Agriculture Program (GIA)

Traci Griffin, CRC for Greenhouse Accounting

KEY MESSAGES

Agriculture represents a substantial component of net greenhouse gas emissions from Australia. Current estimates, that Agriculture produces almost 20 per cent of Australian emissions, are based on defaults based largely on northern hemisphere data, resulting in a high degree of uncertainty of accuracy for Australian conditions. Data representative of Australian conditions is required to ensure appropriate and equitable management of greenhouse emissions by industry and government.

Greenhouse in Agriculture (GIA) is a national program, a collaboration of research agencies researching emissions from Australia's grain, cotton and dairy industries to provide this data. This abstract focuses on GIA's work with the grains industry.

The principal greenhouse gas emitted from the grains industry is nitrous oxide, which has global warming power 310 time that of carbon dioxide. Nitrous oxide emissions from agriculture are principally from the disturbance of soils (cropping and pasture activities), nitrogen fertiliser use and animal excreta.

AIMS

The GIA program aims to:

- Ensure that accounting of greenhouse gas emissions from Australian grain farming systems is accurate and representative of Australian conditions.
- Identified management practices for the management of greenhouse emissions are in accord with sustainable agricultural practices.
- Create awareness in the grains industry and confidence within the policy community of nitrous oxide emissions from dryland wheat and sustainable methods for abatement.

BACKGROUND

As a signatory to the United Nations Framework Convention on Climate Change, Australia is committed to providing an annual inventory of its greenhouse gas emissions. The National Greenhouse Gas Inventory (NGGI) is compiled by the Australian Greenhouse Office (AGO).

The NGGI identifies agriculture as Australia's second highest emitter of greenhouse gases. The data used to calculate agriculture's profile is largely sourced from the Northern Hemisphere. Consequently the accuracy of this data for Australia's profile has a very high degree of uncertainty.

As the focus on climate change and the need to reduce greenhouse emissions intensifies both nationally and internationally, Australia needs to establish measurement techniques and emissions data representative of Australian conditions to validate emissions profiles attributed to agriculture.

Greenhouse in Agriculture Program GIA

Established in 2003 under the CRC for Greenhouse Accounting, the GIA program is a collaboration of agencies researching greenhouse emissions from Australian agricultural industries to achieve the above aims. The program has two principal project areas:

1) Research

The research team includes the University of Melbourne, CSIRO Atmosphere Research, the Victorian Department of Sustainability and Environment, the Victorian Department of Primary Industries and the Department of Agriculture Western Australia.

Focus of research is a measurement program to determine nitrous oxide emissions and to quantify the influence of management factors on emission rates from dryland wheat systems. An initial research

site was established at the Rutherglen Research Institute in Victoria. The methodology and results to date for this site are contained in the 2005 Crop Updates abstract and poster titled “Reducing uncertainty from greenhouse emissions”. A second site will commence operations in Western Australia in 2005, running until 2007.

2) Partnerships, Communication and Extension

This project is the mechanism for developing and maintaining communication links and working relationships between the research team, industry organisations and grain producers. The project aims to increase awareness about the relevance of greenhouse to the grains industry and ensure industry and community’s knowledge development is based on sound science. Activities of the project include:

- Developing relationships with grain industry groups and producers to understand specific need’s and processes for disseminating information by GIA to the industry and to raise awareness about greenhouse and communicate industry’s needs to the researchers.
- Coordinate an industry consultation group with representative of the grains industry to provide input into future direction of research and provide evaluation of research outcomes to ensure relevance and appropriateness to industry.
- Coordinate a National Liaison Panel for greenhouse in agriculture. Panel draws together various agricultural industry groups and federal and State policy agencies to discuss strategic elements of greenhouse in Australian agriculture.

CONCLUSION

The Greenhouse in Agriculture program will ensure Australia’s greenhouse emissions profile is accurate and based on sound science. This information is essential to ensure the grains industry has a true and accurate understanding of its emissions and potential emissions reductions. This information is also crucial to ensure internationally Australia and the industry can negotiate future policies and agreements with confidence.

KEY WORDS

greenhouse, emissions, nitrous oxide

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Grains Greenhouse Accounting framework

D. Rodriguez, M. Probust, M. Meyers, D. Chen, A. Bennett, W. Strong, R. Nussey, I. Galbally and **M. Howden**

Agriculture contributes around 20% of Australia's total net greenhouse gas emissions. Nitrous oxide and methane are the main gasses lost from agricultural systems. Nitrous oxide and methane are powerful greenhouse gasses with global warming potentials of 310 and 21 times that of carbon dioxide, respectively.

While methane emissions are mainly from livestock, nitrous oxide emissions are predominantly from activities relating to the soil, i.e. disturbances due to cropping and pasture activities and the addition of fertiliser to the soil.

Funded by DPI Victoria, GRDC, CSIRO, AgWA, and the University of Melbourne, *the Grains Greenhouse Accounting Framework* is a spreadsheet that can be used to estimate emissions of greenhouse gases from Australian grain production systems.

The spreadsheet is customised for the three zones of the GRDC, i.e. Northern, Southern and Western. The user-friendly web based spreadsheet allows farmers to insert values from their own farming system, i.e. energy sources, yield and fertiliser details to develop an estimation of greenhouse emissions from their enterprise. The spreadsheet also provides information on:

- the nature of greenhouse gases;
- how greenhouse gases are estimated; and
- mitigation methods for the grains industry.

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Contact details for principle authors

Author	Organisation	Location	Phone	E-mail
Megan Abrahams	Department of Agriculture	Geraldton	9956 8540	mabrahams@agric.wa.gov.au
Geoff Anderson	Department of Agriculture	Merredin	9081 3104	ganderson@agric.wa.gov.au
Fiona Barker-Reid	Department of Primary Industries, Victoria	Rutherglen	02 6030 4500	Fiona.Barker-Reid@dpi.vic.gov.au
Anne Bennett	Department of Premier and Cabinet	Perth	9222 9353	abennett@dpc.wa.gov.au
Bill Bowden	Department of Agriculture	Northam	9690 2149	bbowden@agric.wa.gov.au
Paul Carmody	Local Farmer Group Network	Crawley	6488 1987	lfgn@cyllene.uwa.edu.au
Chris Carter	Department of Agriculture	Geraldton	9956 8501	ccarter@agric.wa.gov.au
Neil Coles	Department of Agriculture	South Perth	9368 3617	ncoles@agric.wa.gov.au
Bill Crabtree	Crabtree Agricultural Consulting	Northam	9622 8815	bill.crabtree@wn.com.au
Nick Drew	Fertilizer Industry Federation of Australia		02 6230 6987	fertilizer@fifa.asn.au
Meredith Fairbanks	Department of Agriculture	South Perth	9368 3448	mfairbanks@agric.wa.gov.au
Imma Farré	Department of Agriculture	South Perth	9368 3475	ifarre@agric.wa.gov.au
Ian Foster	Department of Agriculture	South Perth	9368 3642	ifoster@agric.wa.gov.au
Ross George	Department of Agriculture	South Perth	9368 3863	prgeorge@agric.wa.gov.au
Tracey Gianatti	Grower Group Alliance	Crawley	9380 3410	gianatti@agric.uwa.edu.au
Traci Griffin	Department of Primary Industries, Victoria	Rutherglen	02 6030 4596	traci.griffin@dpi.vic.gov.au
Douglas Hamilton	Department of Agriculture	Three Springs	9954 3339	dhamilton@agric.wa.gov.au
Mohammad Hamza	Department of Agriculture	Merredin	9081 3122	mhamza@agric.wa.gov.au
Richard Harper	Forest Products Commission	Rivervale	9475 8824	richardh@fpc.wa.gov.au
Andrea Hills	Department of Agriculture	Esperance	9083 1111	ahills@agric.wa.gov.au
Renaye Horne	Department of Agriculture	Geraldton	99568 528	rhorne@agric.wa.gov.au
Frances Hoyle	University of Western Australia	Crawley	6488 7345	fhoyle@agric.uwa.edu.au
Ross Kingwell	Department of Agriculture/UWA	South Perth	9368 3225	rkingwell@agric.wa.gov.au
Ian Kininmonth	Department of Agriculture	South Perth	9368 3408	ikininmonth@agric.wa.gov.au
Angelo Loi	Department of Agriculture	South Perth	9368 3907	aloi@agric.wa.gov.au

Author	Organisation	Location	Phone	E-mail
Ian Maling	Silverfox Solutions Pty Ltd	Bentley	9361 0955	imaling@silverfox.net.au
Dan Murphy	University of Western Australia	Crawley	6488 7083	dmurphy@agric.uwa.edu.au
Richard O'Donnell	Department of Agriculture	Northam	9690 2246	rodonnell@agric.wa.gov.au
Caroline Peek	Department of Agriculture	Geraldton	9956 8519	cpeek@agric.wa.gov.au
Sally-Anne Penny	Department of Agriculture	Esperance	9083 1111	sapenny@agric.wa.gov.au
Wayne Pluske	Nutrient Management Systems	Applecross	9351 2488	nutrientmswa@optusnet.com.au
Bill Porter	Department of Agriculture	South Perth	9368 3677	bporter@agric.wa.gov.au
Paul Raper	Department of Agriculture	Bunbury	9780 6295	praper@agric.wa.gov.au
Jeff Russell	Department of Agriculture	Northam	9690 2256	jrussell@agric.wa.gov.au
David Stephens	Department of Agriculture	South Perth	9368 3346	dstephens@agric.wa.gov.au
Peter Tozer	Department of Agriculture	Geraldton	9956 8524	ptozer@agric.wa.gov.au
Tress Walmsley	Department of Agriculture	Busselton	9753 0303	twalmsley@agric.wa.gov.au
Phil Ward	CSIRO	Wembley	9333 6616	Phil.Ward@csiro.au
Cameron Weeks	Mingenew-Irwin Group/Planfarm	Geraldton	9964 2974	weeks@wn.com.au