Water use efficient farming systems for the Mallee

Summary
The project was aimed at improving water-use efficiency (WUE) and profitability across the tri-state South Australia (SA), Victoria (Vic) and New South Wales (NSW) Mallee, increasing participative research, development and extension (R,D&E) capacity in regional farming systems. The strategy of focusing on better nutrition and risk management, using soil-specific management and identification of opportunities for breaks (crop and pasture), has proven to be effective and valuable. Large WUE and profitability gains with high rates of adoption have been identified through an extensive field trial and extension program involving researchers, growers and advisers. These have been tested and demonstrated during the four-year project, leading to changes in practice.

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Conclusions
There are opportunities for Mallee growers to increase yields, profits and WUE through the use of soil-specific management, while controlling risk. Using a variable rate approach allows for improved profit-risk returns. nitrogen (N) applications on sands are typically a lower risk investment than on heavy soils.

Combining field research, grower input and, simulation modelling supported by the field validation to inform economic risk analysis - can be very valuable in developing recommendations that recognise the key role of risk in determining grower preference for management options. These will not always be an option - because of grower’s aversion to risk - for maximising profits.

The value of break crops and medic-based, regenerating pastures has been demonstrated by wheat yield benefits evident for up to three years. Using the outcomes of the project, growers and advisers have been provided with thorough and well-understood field experimentation results, supported by analysis of long-term and risk implications using simulation modelling, together with multiple paddock-scale trials using growers' machinery.

The project has continued to highlight the capacity to improve Mallee farming systems by focusing management and investment on sandy soils. At trial sites and on-farm paddock trials, sandy soils routinely provided the greatest returns on investment from nitrogen (N) inputs and had high break-crop impacts, but WUE on these soils often remained low. While this and previous projects have gone a long way to improve the management of the region's sandy soils, there is still great capacity to improve management, and subsequent increases in productivity and profitability, to deliver significant environmental benefits to the region.

Recommendations
Soil-specific fertiliser applications in the Mallee are recommended for growers wanting to achieve higher production and economic returns on N in sandy soils while avoiding over-fertilising constrained, heavy soils where there is higher risk and lower returns. Variable rate fertiliser in typical Mallee dune-swale paddocks can facilitate improved WUE and productivity while providing better risk management.

There is the potential to reduce inputs on constrained soils where the traditional blanket rate has led to over-fertilisation, but it is important to be aware of boundaries, such as where major subsoil constraints (SSC) exist. It is important to monitor soil nutrition following a series of high-yielding years where soil reserves may end up being over-exploited.

The project has demonstrated a high potential for WUE gains. Major yield gaps still exist, however they have the potential to be reduced - particularly on sand.

Attention to diagnosing and dealing with complex issues, including non-wetting soils, poor subsoil nutrition, diseases, hard
pans, micro-nutrient deficiencies and leaching may have the potential to improve N-use efficiency, water use and profitability.

Mallee growers can be more confident about the level of benefit from break options (crops and pastures) on subsequent crops. Break benefits can be reasonably consistent across different seasons and soils. The reliability of the response to break effects should be evaluated as a cumulative benefit over three post-break seasons. This is likely to be more reliable than the profitability of the break year/s. The challenge is identifying and responding to seasonal opportunities for lower cost or more profitable break years.

Growers looking for increased soil N from fixed amounts in residues, and increased N supply potential for more than one year, should consider medic-based pasture and pulse break crops. Growers looking for a rhizoctonia disease break should consider canola or mustard.

Outcomes

The project generated very strong support for the use of soil-specific N management (variable rate) to improve profitability and WUE from Mallee cropping paddocks. This conclusion includes consideration of return risks on N fertiliser investment and aversion to risk. Shifting fertiliser inputs from heavy, constrained soils to sandy topsoils has had significant profit and WUE benefits. In further economic analysis, risk-averse land managers were found to benefit from increases in the level of N fertiliser applications on sandy dune soils above what is considered district practice. WUE on the dune soils could be increased by up to 90% through increasing the level of N applied on sandier soils.

There were also common, cumulative benefits to subsequent cereals of 1t/ha for up to three years after break crops such as canola, lupins, peas or medic-based pastures. Significant cereal benefits were found on some soils in the third crop after the break, with the final set of third-year effects measured in the 2013 harvest. Results have been supported by soil biology analysis of disease and N supply potential impacts. Surveys conducted showed that adoption of zone-specific N management rose by 32% and 40% between 2008 and 2012 in the SA and Vic Mallee, respectively and 56% and 75% of growers (SA/Vic Mallee, respectively) were using variable fertiliser application in 2012.

A major objective of this project was to increase the establishment of participative farming systems (R,D&E) capacity in key districts with high potential for WUE gains. The project has achieved a very high level of success. The Mallee Sustainable Farming (MSF) site at Karoonda has become the major RD&E site in the SA Mallee and there have been more than 175 attendees at recent field days.

A wide range of participating organisations, in addition to the core MSF and CSIRO-run activities, have added value to the site and given it more prominence.

They include: SARDI, legume pastures; University of Adelaide (UA), soil P and soil biology research; SARDI, rhizoctonia studies, barley agronomy trials; PIRSA soils, residual effects of claying and delving; SA Murray-Darling Basin Natural Resources Management (SA MDB NRM), soil water and weather measurements available online; CRC Future Farm Industries, mixed farming options; and commercial herbicide trials (e.g. Bayer). There has been no past level of participative RD&E activity for grain growers in the region.

During the period of the WUE project, MSF has been able to greatly increase its capacity to communicate and deliver to grain growers. It has more than 1000 subscribers and a highly developed network of participative R,D&E activities across the tri-state region. This includes successful, proactive development by MSF and its partners of a new range of R,D&E activities around the Ouyen region in the Vic Mallee following the closure, at the start of this project, of Walpeup as a Department of Primary Industries (DPI) research station.

Achievements/Benefits

The project aimed to achieve improvements in WUE and also build localised RD&E capacity to sustain ongoing farming systems’ improvements. It has achieved this during the period of the WUE project. MSF - with more than 1,000 members and a highly developed network of participative R,D&E activities across the tri-state region - has also been able to greatly increase its capacity to communicate and deliver to growers. Major participative farming systems and RD&E hubs have been developed in regions where they had not existed (e.g. Karoonda) and where major changes had greatly reduced RD&E capacity, such as the Walpeup/Ouyen region, and Kyalite, Merbein and Werrimull (growing districts for MSF impact). Importantly, major new collaborations with advisers and research agencies have evolved and are being sustained beyond the
The project has used multi-soil trial sites, established at major MSF field research centres at Karoonda in the SA Mallee and Ouyen (Vic Mallee), together with additional farmer sites that have followed similar soil-specific themes at a paddock scale. The activities have been run over four years to test the WUE, productivity and risk.

These include:

*A range of continuous cereal systems and the decisions around inputs, timing and agronomy.

*Potential break crop systems; across soils of differing potentials.

To add value to the paddock trials, simulation modelling - The Agricultural Production Systems slMulator (APSIM) and Yield Prophet®, the online crop-production model - has been used to test strategies and recommendations for longer-term and broader-ranging scenarios in collaboration with local, state and tri-state Mallee grower groups.

Work completed within this component of the WUE initiative has shown:

**Soil specific management**

*Field trials and simulations have provided strong support for the use of soil-specific N management to improve profitability and WUE from Mallee dune-swale paddocks and increased reliability of returns from N investment.

*Shifting fertiliser inputs from heavy swales to sandy topsoils can have significant profit and risk benefits, but soil N reserves must be monitored.

*Upfront N (40kg/N/ha) has consistently led to better cereal yields from sands than a split application (9kg/ha at sowing plus 31kg/N/ha at growth stage (GS) 30).

*Recognising when other constraints are reducing the crop N response is important for managing risk (e.g. weeds, diseases, other limiting nutrients), where there were other agronomic issues at Ouyen (weeds and disease on dune soils in 2011) there was little response to N and a small response to phosphorus (P).

*Improved understanding of within-paddock soil types, coupled with support tools such as Yield Prophet, encourages growers to reliably target fertiliser inputs and improve productivity and profitability at paddock and farm scales.

*A new Mallee N tool now incorporates the ability to maximise investment in N by targeting crop responsiveness and also allows recognition of the effect of other limiting factors on N-use efficiency, such as paddocks in need of a break phase for disease. Available from: http://msfp.org.au/tools/msf-n-tool

**Benefits of breaks**

*Break crops and medic-based pastures have led to a relatively consistent average wheat-yield benefit of 0.6t/ha in the following wheat across all soil types at Karoonda.

*Second year break benefits to wheat yield were 0.2-0.3t/ha and there was still a measurable response in 2012 wheat to a pasture break in 2009; possible break benefits in the third year after the break was demonstrated and these need to be considered.

*Break effects have been relatively consistent across soil types with cumulative total yield benefits over two to three years of post-break cereal of 1t/ha, although the main driver of the break effect is likely to differ across soil types.

*N mineralisation potential in 2012 and microbial biomass (MB) N was higher following 2010 break crops and pasture.

*Canola has led to the greatest reduction in *Rhizoctonia* inoculum from heavy swales to sandy topsoils.

*Pasture, lupins and canola breaks resulted in positive four-year gross margin (GM) returns for sandy soil types, but the returns on breaks in the swale were determined by the season in which the break was grown, e.g. missing out on high wheat yields in 2010 came at a significant penalty.

*The systems' benefits of break crops are being realised in commercial Mallee cropping rotations through increased subsequent crop yields driven by grass-weed control, improved N supply and reduced root disease pressure. But Mallee growers need to improve within and across-season break crop selection to increase profitability of the break crop phase.

Knowledge, attitudes, skills and aspiration (KASA) evaluation completed by MSF at the start and the end of this project, in conjunction with the Low Rainfall Collaboration Project (LRCP), has shown that Mallee growers are responding to the key messages developed by this project with 80% of respondents in the exit survey saying they have used some form of zonal management, up from 57% in the entry survey. And 67% of those growers using zone management were implementing variable rate fertiliser application with 61% also applying in-crop fertilisers to specific soil types. In the entry survey, sown
broadleaf break crops represented 3% of the total cropping area, however the exit survey has shown a fourfold increase in the area of sown break crops on Mallee farms.

The use of cropping consultants by SA Mallee growers has increased from 26% in 2009 to 38% in 2012. This is more than double the percentage gain of any region in Australia studied in the 2012 CSIRO-GRDC survey. The SA Mallee also had the largest increase in numbers of growers using soil testing during the same period. Vic Mallee has the highest proportion of growers varying fertiliser by soil zone of any region evaluated in the study, increasing from 63% to 75%. SA Mallee increased from 50% to 56%.

There are opportunities for Mallee growers to increase yields, profit and WUE through the use of soil-specific management while also controlling risk. Using a variable rate approach allows for improved profit-risk returns with increased N applications on sands typically being a lower risk investment than on heavy soils. The value of break crops and low-input, medic-based regenerating pastures has been demonstrated with wheat yield benefits evident for two and, in some cases, three years. Using the outcomes of this project, growers and advisers have been provided with thorough and well-understood field experimentation results, together with multiple paddock scale grower trials using their machinery.

Other research

The project has demonstrated large improvements to WUE on sandy soils, but there is still a substantial opportunity to increase WUE. This is demonstrated by the experiments and, more so, across growers' paddocks. Finding ways to more readily diagnose the likely range of factors affecting performance on sandy soils, and characterising and addressing them, will be an important step. It is likely to be a suite of factors that will vary in different locations and situations. It will most likely be important to pursue the potential of other treatments aimed at improving establishment, early vigour and root growth through improved nutrition (including at depth) and overcoming non-wetting problems.

The study has also demonstrated that there is benefit in better understanding of the dynamics of N and other nutrient cycling in stubble-retained systems. The N supply potential from the soil is important in a low-input system and gaps in knowledge of how to account and manage for likely N supply through the season are apparent. Its importance was clearly demonstrated in this project.

Improving grass-weed management options (particularly brome) and better understanding of strategies for sustainable management of populations will be important. As herbicide resistance increases, the reliance on non-herbicide and rotational options needs to increase: more can be done to evaluate best-practice options.

The MSF/LRCP surveys indicate that the dominant reason for growing break crops is to control grass weeds. This is supported by a surprising number of growers who use double breaks. Of the growers who use break crops, including pastures, 72% say they have employed two successive breaks. Developing ways to better test, evaluate and adapt long-term strategies for profitable grass-weed management will be valuable in a low-rainfall/low-input systems' environment.

The ability to reduce the opportunity cost of growing break crops and taking advantage of potential for second and third-year break effects are important for maximising the value from break options. Testing and evaluating low-cost/low-risk break options that can be employed when seasonal conditions for cropping are looking poor could offer major benefits. 'Improved fallows' and low-cost seeding/regeneration methods may offer the break benefits to subsequent crop yields, but with more flexibility and less potential opportunity cost in the break year.

The project has contributed to the development of Mallee Midas, a whole-farm bio-economic model for evaluating the likely extent of crop/land management options to maximise whole-farm profit, given constraints and the range of soil types. Existing output from the model reflects the low use of break crops commonly observed in the past, but it does not include updated break-effect information based on this project or the crop sequence project. Once 2013 break effects are measured (three years after break phase) the profit-maximising extent of break crops will be evaluated using the Mallee Midas tool and the new data.

**Intellectual property summary**
There is no commercial IP from this project. IP protection strategies relating to model development are consistent with original IP arrangements for the project.

**Additional information**


