INVESTING IN WATER USE EFFICIENCY YIELDS RESULTS

GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

Water Use Efficiency research is transforming the productivity potential of Australian farming systems, demonstrating that efficiency gains of 20-40 per cent are possible with optimal pre-crop and in-crop management practices.

The challenge

One of the greatest barriers to improving farm productivity in Australia is water. Not simply a lack of it or variations in the timing and intensity of rainfall events, but efficiently capturing, storing and converting every millimetre into plant biomass and grain yield.

CSIRO estimated that long term yields decreased by 1.1 per cent each year from 1990 to 2015 due to a reduction in rainfall and increase in heat (Hochman, Gobbett and Horan, 2017).

In simple terms, water use efficiency (WUE) is a measure of a crop's capacity to convert water into yield using water stored in the soil and rainfall during the growing season. The amount of water used by a crop is usually defined as transpiration (from the leaves) plus evaporation (from the soil) although it's also important to factor in water lost to the crop in run-off and drainage.

Over the past ten years, GRDC research investments have established that water productivity (crop yield per unit of water used) increases of more than 40 per cent are possible by using improved pre-crop and in-crop management practices.

Current investments have extended their focus from optimising the water use efficiency of individual crops to considering the efficiency of cropping systems. That is, assessing profit per hectare/ millimetre/year rather than simply evaluating yield/mm.

The response

In 2008, GRDC commenced a five-year WUE Initiative (CSP00111) in collaboration with the CSIRO, challenging growers and researchers to lift the WUE of grain-based production systems by 10 per cent across Australia's southern and western cropping regions.

The initiative built on the progress and outcomes of multiple research projects that the GRDC had previously invested in and focussed on three core aspects: improving water capture, increasing soil water storage and lifting the conversion of stored soil moisture into crop productivity.

The initiative involved $17.6 million in investments across 16 diverse research projects which were organised into four themes - integrating break crops, managing summer fallows, managing in-season water use and managing variable and constrained soils.

It took a participatory approach, with growers and advisors helping

guide WUE research priorities in conjunction with the CSIRO. This ensured the research was targeted, relevant and practical.

Field trial sites were established across the southern and western GRDC regions, drawing on the regional experience of growers, advisers, researchers and farming systems groups and ensuring the research covered a broad spectrum of soil types, environmental conditions and rainfall zones.

The impact

The WUE Initiative is one of the largest research projects ever undertaken in Australian agronomy.

Its scale, depth and robust validation has been a key driver in raising awareness among growers and advisors of the critical link between WUE, pre-crop and in-crop management practices and farming system productivity.

The WUE Initiative research clearly demonstrated the importance of pre-crop management to the WUE and yield of cropping systems. Pre-crop management includes practices that increase soil water capture and storage in the months and years leading up to sowing such as fallow weed management, rotation choice, long-term stubble retention and minimum tillage. These practices can contribute up to two-thirds of the WUE of grain systems.

Growers who successfully manage the pre-crop phase can then optimise the effectiveness of their in-crop management practices such as sowing date, nutrient, weed and disease management and capitalise on the increased soil water storage capacity.

The research found that optimal pre-crop and in-crop management in combination can deliver WUE gains in the order of 20-60 per cent, highlighting the importance of identifying profit drivers within a farming enterprise and prioritising management practices accordingly. This has the potential to significantly improve the long-term profitability of Australian farming systems.

Validation

With the WUE initiative's results far exceeding the initial target of attaining a 10 per cent lift in WUE within Australian grain production systems, the research suggests that Australian grain growers have become the most advanced in the world for sustaining crop production in the face of declining rainfall.

The final reports on the WUE Initiative detailed a range of notable economic, environmental and social outcomes from improved integrated management practices and greater engagement and collaboration within the research community.

Some key findings from the trial work include:

- A vetch break crop at Hopetoun, Victoria, increased WUE of the following two wheat crops by 16 to 83 per cent relative to wheat on wheat.
- Controlling summer fallow weeds resulted in an average 60 per cent increase in seasonal WUE (harvest to harvest rain) and an average $5.60 return on each dollar invested.
- Slow developing wheat varieties sown early increased WUE by 33 per cent at Junee, NSW in 2012 and 21 per cent at Temora, NSW in 2011 relative to mid-fast varieties sown in mid-May.
- In Mallee dune cropping systems, increasing nitrogen inputs on deep sands can increase WUE by up to 91 per cent relative to district practice.
- Trials in Victoria and southern NSW found maintaining row spacing at 30cm increased WUE by 6 to 13 per cent compared with 37.5cm row spacing in a wheat-canola sequence.
- Gypsum applied to responsive soils along Western Australia's south coast lifted WUE from 11 to 17 kilograms per hectare per millimetre and crop returns increased by almost $200/ha over four years.

The outcomes and recommendations have been widely accepted by leading growers and advisers, particularly within GRDC's western and southern cropping regions, resulting in the adoption of improved integrated farming practices and productivity gains.

These growers and advisers are an important legacy for continued practice change across the Australian grains industry.

Growers in regions with an average 300 to 400 mm of rainfall and yields of 2.56 tonne for wheat, 2.23 for barley and 1.37 t/ha for canola will benefit from this research. In these regions an increase of 1 per cent in wheat, barley or canola yields is worth $7.97, $6.45 and $7.40 per hectare respectively.

Southern NSW agronomist Greg Condon has been involved with WUE research projects for more than 12 years and said the work had underpinned an evolution in the management of summer fallows and farming sequences in the region.

He said the depth and adoption of the project outcomes highlighted the value of long-term research investments.

“Protecting soil water is a real productivity driver and the work has enabled us to establish what management practices are and aren’t important to the profitability of our farming systems,” he said.

“We’ve certainly started to see the benefits of the WUE research work in recent years. For instance it’s been a game changer for growers who have managed summer weeds effectively and been able to grow a profitable crop on decile one or below rainfall.

“Many crops are dry sown in our region and the research work has given us the confidence to strengthen that practice, allowing earlier sowing opportunities which has a whole of farm benefit from both a productivity and profitability perspective.

“At the same time, it’s yielded valuable information on the relationship between stubble management and soil water storage, particularly within mixed farming enterprises. The research debunked the theory that grazing stubble was directly competitive with no-till farming, highlighting that productivity is far more impacted by ground cover management than soil compaction from sheep. It confirmed that the optimum benchmark ground cover retention rate of 70 per cent or greater is preferred for rainfall capture and retention.

“This research has encouraged an evolution in farming systems in southern NSW and it’s on-going. We’re seeing leading growers take the outcomes of the WUE work a step further, managing their stubble and the diversity of their rotations to maximise early sowing opportunities and the benefits of crop sequencing.

“A focus on summer weeds has made us more conscious of crop water use and what’s left at the end of the season. This enables us to be more strategic around crop choice and maximise productivity per millimetre of soil water.”

To validate the impact of the WUE Initiative, GRDC commissioned an independent evaluation of the Initiative by Agtrans Research ‘An economic analysis of GRDC investment in Water Use Efficiency’.

The evaluation stated that GRDC’s investment in 13 of the WUE Initiative projects with total combined investment of $25.4 million (present value terms) has been estimated to produce total gross benefits of $93.2 million (present value terms) providing a net present value of $67.8 million.

The benefit-cost ratio was found to be 3.66 to 1 over 30 years using a 5% discount rate and an internal rate of return of 18.5%.

The outlook

WUE continues to be a key theme across a range of GRDC research investments totalling more than $1.8 million into overcoming production constraints, lifting crop productivity and improving overall farming system efficiency and profitability through integrated agronomic and business management strategies.

This research builds on work undertaken through the WUE Initiative and includes investments such as the northern farming systems project which is investigating whether system performance can be improved by modifying the farming system. The project includes six regional sites stretching from central Queensland to central west NSW including a core site at Pampas on the eastern Darling Downs.

These regional sites are comparing a set of five to eight system modifications to the local baseline farming system, while the core site is comparing 34 different system treatments, which vary in their crop intensity (the number of crops sown/year), the use of break crops and/or legumes, and nutrient supply strategy.

In 2017, an additional four sites were added as part of a southern NSW-focussed project (CFF00011) which is reviewing the current cropping system efficiency in southern NSW, assessing the impacts of different sequence and management strategies on system efficiency, profitability and sustainability, and developing regional recommendations that consider economic, climate and price risks and the long-term sustainability of the cropping system.

Over the life of the projects, each experimental farming system will be compared in terms of total grain production and quality, economics (inputs and returns), efficiency of water and nutrient use, changes in soil nutrient stocks and soil health indicators, and dynamics and populations of soil pathogens and weed populations. This information will help researchers understand the strengths and weaknesses of different systems and identify any future risks associated with particular system modifications.

Other research to evolve from the WUE Initiative includes Early Sowing of Wheat projects (CSP00178 and 9175069) and the Optimising Canola profitability (CSP00187) project which is assessing the WUE impact of different tactical agronomy packages as part of its trial work.

These projects are helping deliver tangible benefits in terms of crop yield and overall farming system efficiency and profitability.

For example, early sowing emerged as a necessary 'next-step' to capitalise on the benefits of better summer fallow management demonstrated within the WUE Initiative. Earlier sowing increases the frequency of planting opportunities and allows more crop to be sown and flower on time.

Early sown wheat crops yield more because less water is lost to evaporation, roots grow deeper, water is converted to dry-matter more efficiently and a longer stem elongation phase increases grain number.

Research undertaken as part of the Early Sowing of Wheat project CSP00178 has encouraged early sowing practices backed by regional guidelines on seasonal suitability for early sowing and appropriate varieties and management.

Results from the research showed a trend across the western and southern growing regions toward sowing earlier between 2008 and 2015. In WA the rate of change was 1.3 days/year, in South Australia 1.4 days/year, Victoria 2.0 days/year and southern NSW 1.1 days/year. During 2013–2015 42 per cent of fields from across all regions were sown prior to May 10, which is the approximate optimal sowing date for current elite fast developing spring cultivars in most environments of southern Australia.

Research into genotypes and regionally appropriate agronomic management packages is continuing, which will enable growers to maximise the yield advantages of early sown winter wheats into the future.

Results from GRDC's suite of WUE-related projects will continue to be reported through the traditional media, Ground Cover, GRDC's digital channels and CRM communications, as well as through various public forums such as the GRDC Grains Research Updates.

References and resources

Economic performance and system water-use-efficiency of farming systems
https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2019/02/economic-performance-and-system-water-use-efficiency-of-farming-systems

Relative importance of various factors on the water use efficiency of wheat
https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2019/02/relative-importance-of-various-factors-on-the-water-use-efficiency-of-wheat

GRDC codes: CSP00111, DAS00089, CSP00208, CFF00011, CSP00187