FINAL REPORT

GRDC Grains Research & Development Corporation

Central Queensland Sustainable Farming Systems - Phase 3

DAQ00116

Project Details

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Summary

This project employed a participatory development and extension (D&E) approach involving on-farm trials and capacity-building activities to improve the economic and environmental performance of grain and mixed farming enterprises in central Queensland (CQ). The project's activities delivered (1) enhanced knowledge and understanding of key system variables that underpin grain and mixed farming businesses, and parameter values for these variables in relation to a range of environmental and management factors, (2) new and refined practices, technologies and management strategies to sustain the profitability of cropping and (3) products and information to support continuous improvement in farm business performance.

Conclusions

The project's outputs highlight some clear strengths and deficiencies in relation to grain cropping practices as well as emerging challenges facing the industry in CQ. Whilst most grain growers are adept at growing grain crops profitably in the most variable climatic region in Australia using a number of conservation farming tools and techniques, some are more successful than others. From a productivity perspective, practices clearly in need of improvement include:

- managing for soil type variation and crop performance zones
- linking cropping decisions and nutrient management to soil fertility testing
- using decision support and risk management tools to underpin cropping decisions and crop sequences
- using remote sensing, soil conservation and other precision agriculture (PA) technologies for managing crop and soil variability, erosion, drainage and surface water flows.

Cropping frequency and water use efficiency (WUE) have attracted much attention in recent years. The outputs of this and previous projects confirm the ability of CQ grain growers to produce more grain from less water using an opportunity cropping strategy during a decade of low rainfall years (2000-2009) and still maintain a profitable industry. The outputs also demonstrate the potential impacts of infrequent and unplanned planting opportunities on long-term cumulative gross margins for crop sequences. In the CQ environment, an 'aggressive' cropping strategy designed to increase the cropping frequency by employing lower soil water triggers and more flexible planting windows compared to conventional (conservative) opportunity cropping will be more profitable only if unplanned planting opportunities that result in highly profitable crops can be successfully exploited. The project's outputs lead to the conclusion that the ability of the average grain grower (the majority of grain growers in CQ) to respond to unforseen or unplanned planting opportunities is limited by a number of factors including technical, mechanical, financial and resource capabilities.

Weed control represents a highly significant input cost for grain production in CQ. Herbicide options for control of feathertop Rhodes grass (FTR) and other weed controls have been identified and delivered through affiliated research projects (e.g. DAQ105), but uptake has been variable due to (1) the need for upscaling from small plot evaluations to large-scale, on-farm and regional validation, (2) the need for improvements in grower and adviser spray application knowledge and standards, and (3) industry-sponsored on-farm trials involving alternative off-label herbicide products and application parameters that are often not consistent with agricultural best practice and serve to undermine the adoption of effective weed control and integrated weed management best practice in the region.

The run-down of phosphorus (P), nitrogen (N) and other key nutrients in many CQ soils represents a highly significant emerging research, development and extension (RD&E) challenge and a future production constraint for the grains industry in the region. Although N deficiencies are relatively easy to replenish through cultural and other techniques, replenishing run-down reservoirs of P, potassium (K) and other elements is complicated and expensive. Significant progress in this area will require a dedicated long-term R&D effort.

The contribution of this project to the development of the whole farm integration model (APSFARM) represents a quantum leap forward in terms of capacity to develop better adapted farming systems with increased flexibility and more sustainable economic growth.

Recommendations

Soil nutrient management and integrated weed management (IWM) are among the highest priorities of CQ grain producers. Effective management of soil nutrients is currently hampered by a lack of understanding of interactions between key nutrient elements (N, P, K, sulfur (S), zinc (Zn)). The relatively low adoption of some very basic best-management practices such as soil nutrient testing is indicative of the need for ongoing extension and training. Efficacy of commercial weed control, particularly against grass weeds such as FTR (*Chloris*) and summer grass (*Digitaria*), is highly variable and often characterised by poor application standards and use of illegal (off-label and unregistered) herbicides. A significant problem for weed control also stems from the apparent failure of herbicides that are successful in research trials to provide adequate control in a commercial farm setting.

Key recommendations for future RD&E are as follows:

1. Greater engagement with the private agronomist and agribusiness industries and collaboration for delivery of D&E.
2. Targeted training and development in the areas of soil N management aimed at greater adoption of well-established practices and technologies.
3. A dedicated research program to investigate and elucidate relationships between key nutrients such as P and K and crop health.
4. Training and development in spray application best practice.
5. Upscaling of weed control research outputs, including herbicide options from small plot evaluations to commercial scale assessments.

Outcomes

The outputs of structured project evaluation surveys in 2009 (mid-term), 2010 (end-of-project) and written evaluations conducted after key project activities showed that the vast majority of grain growers in CQ acknowledged significant or highly significant immediate and potential future economic, environmental and social benefits arising from the project.

Economic benefits

The project has delivered (1) technological and technical solutions for IWM, (2) new knowledge of and ground rules for optimisation of the cropping system and key system variables (cropping strategy, agronomic variables, plant available water (PAW), soil nutrients), and (3) decision support tools for managing inputs and profitability. All respondents in the 2009 survey indicated a significant improvement in their farming practices and the production system resulting from the application of information provided by the project. Key current and future benefits from on-farm trials identified by respondents include:

- guidelines for agronomic variables (row spacing, plant populations)
- options and guidelines for weed management
- guidelines for managing zero till and controlled traffic
- guidelines for soil health, fertility and fertiliser management
- drought proofing of paddocks through tram tracking and zero till with 30 per cent fuel savings and 15 to 20 per cent better crops.

Environmental benefits

Working in collaboration with the Fitzroy Basin Association (FBA), the project has demonstrated significant short and long-term dollar and system benefits in relation to the key environmental challenges of soil erosion and overland water flow management on cropping land in CQ using state-of-the art technologies. The project's outputs have shown that:

- Optisurface™ computer software technology has the potential to provide highly accurate solutions for drainage and soil loss prevention with up to 90 per cent reduction in the requirement for earthworks and soil movement compared to the traditional cut and fill approach
- erosion rills on cropping land are costing, on average, $48/ha every year on Open Downs soils in CQ.

Social benefits

Almost all respondents in the surveys identified networking and capacity building among the most significant benefits of the project.

The percentage of survey respondents aware of the project's activities and outputs:

- extension of better management of FTR - 77%
- extension of better management of other weeds - 76%
- Cropping Central publications - 73%

- extension brochures - 68%
- Assessing Stubble Cover publication - 64%
- CQ Crop Facts - 62%.

The percentage that rated activities and products as 'Useful' (score of 4/5) or 'Highly useful' (score of 5/5):

- Cropping Central publications - 87%
- CQ Crop Facts - 73%
- extension of better management of FTR - 73%
- soil pit days - 68%
- production of extension brochures - 67%
- extension of better management of other weeds - 66%
- healthy soils workshops - 64%
- The Nitrogen Book - 53%
- articles from The Nitrogen Book - 53%
- Assessing Stubble cover publication - 48%.

Achievement/Benefit

Previous farming systems projects in CQ (CQSFS1 and CQSFS2; 1997-2007) were highly successful in fostering widespread adoption of advances in agronomic and natural resource management (NRM) including zero or minimum tillage, IWM, controlled traffic farming and strategic nutrient management. Project CQSFS3 was designed to build on the successes of its predecessors. Research showed that despite the widespread adoption of new practices and technologies, northern farming systems (including CQ) were performing significantly below their water-limited potential productivity. The overarching objective of project CQSFS3 was to optimise the performance of CQ grain cropping systems by fine-tuning existing best practice and developing and implementing new practices, technologies and management strategies. This was achieved through a structured framework of specific outputs and targets grouped into functional themes within each output as follows:

Output 1: Increased knowledge and understanding of the current and potential economic, environmental and social performance of CQ grain and mixed farming businesses; and the sensitivity of this performance to a range of environmental and management factors.
Theme 1. Systems performance

Output 2: New and refined practices, technologies and management strategies that have the potential to improve the economic, environmental and social performance of CQ grain and mixed-farming businesses.
Theme 2. Managing risk and variability
Theme 3. Soil fertility and crop nutrition
Theme 4. Systems water use efficiency
Theme 5. Integrated weed management
Theme 6. Whole farm performance and enterprise integration

Output 3: Products and processes that support farm business managers in implementing improved practices, technologies and management strategies that will result in a continuous improvement in farm business performance
Theme 7. Capacity building

Major achievements of the project under each theme are summarised below:

Theme 1:
Target 1. Potential performance of CQ cropping systems
This study used well validated simulation models to derive a range of values for key system indicators that are likely to apply in CQ cropping systems. The agricultural production systems simulator (APSIM) (v6.0) modelling platform was used to simulate factorial combinations of a range of cropping strategies at two sites (Emerald and Biloela) in CQ using 117 years of recorded weather data (1890-2007).

The results of the modelling exercise show that total cropping frequency and the frequency of occurrence of particular crops are key drivers of productivity and profitability in dryland systems. The 'benchmark' values generated by this study can be used as a guide to what is achievable in these systems.

Target 2. Current performance of CQ cropping systems
We used data from the Grains Best Management Practices (BMP) project and the Australian Bureau of Statistics (ABS) collated in 2008-2009 to obtain a snapshot of grower best practice adoption within the CQ region relevant to CQSFS3 project themes.

The analysis reveals strengths in risk management, soil water management and matching inputs to soil moisture levels and seasonal outlooks. Apparent weaknesses include the areas of regulatory requirements and record keeping. The report provides practice-specific benchmarks that will be critical in targeting future RD&E investment in the region.

Theme 2:
Target 1. Using Southern Oscillation Index for risk management
This activity was designed to provide CQ growers with probabilistic 'rules of thumb' for making planting decisions from a climate variability and risk management perspective. Using wheat and sorghum WhopperCropper databases for Emerald, the effects of antecedent conditions (i.e. soil water at planting, soil plant available water capacity (PAWC) and seasonal outlook) and manageable agronomy (i.e. plant date and row configuration) on yield variability were quantified. The results indicate clear and predictable interactions between SOI phases and plant dates for sorghum and wheat. This information would enable growers to make smarter and more profitable planting decisions.

Target 2. Development and application of widely accessible and user-friendly decision support tools
This group of activities resulted in (1) the production of The Nitrogen Book, (2) development and dissemination of the electronic N fertiliser calculator, (3) delivery of a training workshop on the use of WhopperCropper. Collectively, these tools are the integration of CQ research and on-farm experiences within this and previous projects spanning more than 10 years. They are designed to assist growers and advisers to manage climate variability and key agronomic variables through the optimisation of inputs and smart cropping decisions for maximum yield and profitability.

Target 3. Climate change scenario analyses
The aim of this study was to provide growers, advisers and researchers with a number of modelled scenario analyses detailing potential effects of climate change on grain production as well as strategies to manage these effects. The simulations examined single crop effects, crops within rotation systems and the interaction of these with various soil water thresholds (PAW) for planting.

Based on the input parameters used, the scenario analyses provide useful insights into possible outcomes of climate change and suggest potential adaptive solutions. For example, individual crop yield may increase for a given supply of water. However, water supply may reduce in quantity and the pattern of seasonal occurrence of rainfall is likely to change. This is likely to reduce the overall cropping frequency and the dominant crop type.

Target 4. Dealing with variability in CQ - the role of PA technologies and their potential applications
Project CQSFS 3 worked closely with the FBA and Queensland Department of Employment, Economic Development and Innovation (DEEDI) on a two-year developmental project to assess a range of PA tools and their applications for CQ growers and cropping industries in the region. The project assessed technologies for their systematic potential to improve resource use and decision making for better input management and enhanced profitability of crop production.

This group of activities showed that the technologies assessed in the project were not 'grower friendly', and that they needed a high level of expertise for successful use and adoption. A case-by-case evaluation of the costs and benefits is required to determine the suitability of or investment in PA technologies. The outputs show the enormous potential of topographical information that is routinely collected by many growers for better management of water movement across fields and landscapes to minimise waterlogging and minimise erosion through the use of newly developed computerised technology such as Optisurface™. The outputs show how PA can measure constraints, allowing managers to develop business cases for remediation of constraints, such as waterlogging, soils, agronomy, erosion or compaction.

Theme 3:

Target 1. P fertiliser responses in CQ field crops
The objective of this activity was to determine if application of P fertiliser is warranted, and if so, how much, when and how best to apply it for an economic gain in the major CQ crops in relation to soil type, existing soil P level and fallow length.

The results of experimental assessments and grower trials to date have been inconclusive for cereal crops and to some extent for mungbeans, with mostly nil responses to P fertiliser application. By comparison, a more consistent response to P fertiliser is evident in chickpeas. The conclusion emerging from these studies is that current diagnostic methodology based largely on the Colwell P soil test is largely inadequate to accurately determine the dynamics and plant availability of P in the northern region, particularly across large parts of CQ. Soil nutrient management is rapidly becoming a key production issue in CQ due to declining soils levels of P, K and possibly other nutrients.

Target 2. Cropping intensity, traffic direction and N management in CQ: Two case studies
A ten-year comparative assessment of four management units (paddocks) on two grain cropping enterprises with different soil types resulted in some of the most significant insights and learning produced by the project in relation to some broadly relevant issues identified as RD&E priorities by CQ grain growers - N management, cropping intensity, WUE and controlled traffic direction.

The N fertiliser experiments at Moonggoo confirmed the need for supplementary N application on Open Downs soils. At Kilmore, the high inherent soil fertility of the scrub soil meant that yield response to N fertiliser was unlikely. This outcome highlighted the value (with limitations) of organic carbon (OC) as an indicator of potential soil N fertility. Information and data from this medium-term study were instrumental in the development and validation of a N compendium (The Nitrogen Book and electronic N fertiliser calculator). The calculation of WUE revealed large differences between pulse and cereal crops. The cropping intensity experiment did not confirm the hypothesis that increased cropping intensity would increase returns. The results emphasised the importance of capacity to respond to cropping opportunities and the effect that a single decision can make to financial returns in the short to medium term.

Theme 4: Target 1. Water use efficiencies in CQ
An analysis of on-farm data from commercial cropping enterprises complemented by simulation modelling was used to examine the range of water use efficiencies achieved under a number of cropping options, fallow options and agronomic settings. The output is a water management guide for growers and advisers for benchmarking performance and setting achievable targets.

Target 2. Cropping frequency
An assessment of cropping sequences over 10 years on the Moonggoo and Kilmore case study farms examined the potential for increasing the cropping frequency in CQ as a means of improving the profitability of grain production.

Theme 5:
Target 1. Evaluation of WeedSeeker® technology
Experimental evaluations and demonstrations were conducted to familiarise growers and project staff with the application, benefits and shortfalls of WeedSeeker technology for managing relevant and emerging weed issues in CQ farming systems. These activities have increased awareness among the majority of CQ growers and agronomists, increased interest to own and use WeedSeeker technology and directly influenced growers who already own WeedSeeker booms to adapt their commercial rigs for use in-crop. The project has influenced a shift towards smarter zonal weed management in CQ farming systems - maintaining pace with if not leading the world with these practices.

Target 2. Validation of new herbicide options
Activities included demonstrations and extension of FTR and sweet summer grass management in fallow; small plot evaluations of wheat tolerance to phenoxy[#] herbicides and chickpea tolerance to at-planting and early post-emergence in-crop herbicides. This program of activities has identified cost-effective solutions for grass weeds, increased capacity among growers and their advisers to better manage problem weeds and built enormous social capital with industry throughout the region. Data generated are now available for industry to include in herbicide label registration changes (wheat, chickpea and FTR work) with the potential for a greater number of weed control options available in commonly grown crops.

Target 3. Seed biology and ecology studies

Data on germination biology of sweet summer grass generated in these activities are available for testing and validating the existing glyphosate# resistance model. This will assist growers with deciding when practice changes need to be implemented to avoid development of resistance in key high risk summer grasses of the region.

Theme 6:
Target 1. Land-use performance for major land types
Land type maps and economic performance data prepared for CQ with selections of suitable land types for crop and pasture production can be used by producers to better match land-use performance to land capability. Production and economic performance of each of these land types can be compared for the different land uses and locations in CQ to help improve overall farm profitability.

Target 2. APSFARM - Whole-farm integration
A fully integrated model to simulate a mixed farm with cropping and grazing enterprises is presented. This model will provide the platform for the next quantum leap to improve the economic and environmental performance of mixed farming operations resulting from effective integration of cropping and grazing enterprises and better matching of land use to land capability. This work will help develop better adapted farming systems with increased flexibility and more sustainable economic growth.

Theme7:
Target 1. Extension, training and development
Project CQSFS3 has produced 19 articles in industry publications and professional forums, 11 issues of the Cropping Central newsletter, delivered more than 50 training and development workshops either independently or in partnership with other projects, conducted more than 10 field walks, produced 40 media releases as well as numerous other products to support capacity building and industry development in CQ since 2007.

Other Research

The CQSFS3 team capitalised on two significant industry development opportunities that arose during the course of the project:

1. Support for the Grains BMP program in CQ. The project team worked closely with the BMP project team to develop and deliver BMP and related training workshops from 2008-2010, during which time more than 50 workshops were delivered to over 200 attendees from the grains industry. This process has enabled benchmarking of practices across key aspects of grain cropping in CQ. This outcome will be significant in determining future RD&E prioritisation and resourcing.
2. Evaluation of PA technologies in CQ. The CQSFS3 project team worked closely with the FBA on a two-year developmental project to assess a range of PA tools and their applications for CQ growers and cropping industries in the region. The project assessed technologies for their systematic potential to improve resource use and decision making for better input management and enhanced profitability of crop production.

The outputs highlighted areas for further R&D, in particular, the enormous potential of topographical information that is routinely collected by many growers. This can support better management of water movement across fields and landscapes to minimise waterlogging and erosion by using newly developed computerised technology such as Optisurface™.

Intellectual Property Summary

The project did not produce intellectual property of commercial value. All the information generated by the project is or will be publicly available.