FINAL REPORT

GRDC Grains Research & Development Corporation

Participatory adaptation and mitigation strategies for climate change on the mixed farms of north-eastern Australia

DAQ00163

Project Details

- **Project Code:** DAQ00163
- **Project Title:** Participatory adaptation and mitigation strategies for climate change on the mixed farms of north-eastern Australia
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- **Supervisor:** David Lawrence (Principal Extension Officer)
- **Organisation:** Department of Agriculture, Fisheries and Forestry (formerly Employment, Economic Development and Innovation)
PO Box 102 Toowoomba QLD 4350
- **Contact Name:** David Lawrence
Phone: 07 46881617
Email: David.Lawrence@daff.qld.gov.au

Summary

The past two years has been an extraordinary time to address climate change and the adaptation/mitigation strategies for mixed farming systems in the northern region with ongoing political debate and policy changes on carbon pricing, extreme rainfall and big floods. This project made major progress. It engaged a network of growers and advisers to make a lasting contribution, one that will help growers understand climate change, assess how future climate scenarios may impact on their business and profitability and develop their own farm strategies to manage them. These contributions will support growers to make more informed decisions into the future.

Conclusions

1. Climate change is a contested issue with conflicting views on all aspects of it. Many growers do not understand how it all works but need continuing support to assess the impacts of climate change on their farming systems so they can prepare for possible future climate scenarios.
2. Collating local data to understand climate change, the underlying processes of atmospheric warming and the possible impact on their farms has reduced participants' anxiety but has not made all participants 'believers'.
3. At $23/t CO_2 equivalence, the value of the nutrients in the associated soil organic matter is 23 times higher than the potential return from carbon sequestration and remains the priority for most growers, so the grain industry must not over-sell carbon trading.
4. Cropping becomes less profitable as soil nutrients decline and have to be replaced by fertilisers. In future scenarios (e.g. by 2050), pastures and grazing may be more profitable on many soils than cropping. If this is not recognised and addressed in a more coordinated way between industries (e.g. beef and grains), nutrient declines may be too advanced to rectify economically. If this occurs, large areas of old degraded cropland may be returned to pastures that grow little dry matter and result in low productivity and few soil health benefits.
5. Cropping causes a dramatic decline in soil organic matter. Not only does the subsequent fallow reduce soil carbon levels, it typically provides larger 'pools' of soil nitrate that drive nitrous oxide emissions in saturated soil conditions. Grain production is a major enterprise across the region with increasingly sustainable practices. However, maintaining soil organic carbon and minimising nitrous oxide emissions present two key challenges, as outlined below.
6. The project assessed only a limited range of adaptation and mitigation options. However, the data collected show that modern farming practices in the mixed farming zones can reduce daily greenhouse gas emissions and rebuild soil organic carbon. .
7. Foremost amongst these practices is the use of legume and pasture phases that can sequester soil carbon and have the potential to reduce daily greenhouse gas emissions. These pasture options require continued research, development and extension (RD&E). They may be less profitable than grain alone, so whole-farm profitability may suffer if there is a trend away from crops. Pasture productivity may also 'rundown' due to induced nitrogen deficiency or 'tie-up' in mature plants, especially on old degraded cropping land that is phosphorus deficient and unable to support pasture legume production and nitrogen fixation. It is also unclear if 'total-season' emissions are reduced in ley systems that may have lower daily emissions but in which emissions may continue for longer than from fertiliser applications.
8. It is for this reason that the new formulations of nitrogen fertiliser are of interest. They are currently expensive. However, the results in this project suggest they are worthy of further investigation across a range of soils, seasons and dryland cropping systems to inform future decisions as the need to reduce emissions is likely to increase.

Recommendations

There are three major recommendations for conducting any future development and evaluation (D&E) activities on climate change, adaptation and mitigation in the grains industry:

1. Build climate change work and scenarios into other technical industry projects. Climate change is a difficult topic on which to engage growers. However, building climate scenarios into the assessment of key practices that are valuable for mitigation and adaptation is well received. It is considered practical and many of these practices (e.g. ley pastures to boost soil organic matter) have current as well as future value. It appears from the project's market research and evaluation results that this type of engagement is likely to be more successful for building capacity and supporting adaptation and mitigation than climate change projects that have often been viewed cynically by many growers.
2. Use professional and theoretically sound extension processes. Processes that support growers to go beyond awareness of issues will be critical as complex issues of sustainability and different values continue to emerge. Demonstrations are valuable but on their own are of limited value to build capacity and support

change on farms. In contrast, using data collected on commercial farms and supporting growers to make real-time decisions using their own data continues to have an impact. It builds capacity and encourages action. It is also clearly recognised as having an impact by the participating growers who continue to seek support from projects that engage them with soil tests on their own farms.

3. Consider further research and development (R&D) work on the key issues identified in this project.

Outcomes

The project has helped growers see the continued profitability of their grain enterprises and has reduced over-reactions to climate change that may involve big reductions in the grain areas sown on properties. As grains generally remain the most profitable enterprise, this will help most mixed growers maintain higher economic returns.

The project has also provided local data, encouragement and the skills to boost soil organic matter and maintain soil nutrients for resilience and continued productivity of grain enterprises in variable climates. This environmental outcome has significant economic benefits. By maintaining soil phosphorus levels in cropping phases, growers will maintain the flexibility to use periodic ley pastures to lift soil carbon and rebuild their soil with widespread use of legumes to fix atmospheric nitrogen and maintain productive pastures. However, if they deplete their soil nutrients, any pasture phase will have reduced productivity and much less value for improving soil health for a return to profitable grain production.

Growers will also benefit from project results which highlighted that the value of soil carbon is significantly less than the value of the associated nutrients in soil organic matter. Getting growers to focus on soil organic matter for resilience and productivity benefits, rather than a sole focus on payments for soil carbon sequestration, will have social and economic benefits across the grains industry.

Finally, the project highlighted widespread opportunities to reduce nitrous oxide emissions in grain production systems. Ley pasture systems that use legumes to provide an organic source of nitrogen are likely to be valuable in all but the most intensive grain farming systems. However, the emergence of new nitrogen fertiliser formulations (e.g. Entec® and Agrotain®) is also providing scope to dramatically reduce nitrous oxide emissions from more intensive production systems. While these new formulations are currently expensive and require further assessment to confirm their commercial value, they provide more socially acceptable options with lower emissions for the industry as a whole.

Achievement/Benefit

In just two years the project achieved a lot towards the National Adaptation and Mitigation Initiative (NAMI) goal of having growers utilising knowledge and technology for informed decisions on how to mitigate and adapt to climate change. This required going beyond a 'general awareness' of climate change and helping growers build the capacity to manage possible future climates; that is, to better understand climate change, the process of atmospheric warming, the possible outcomes and implications for their region and the most promising local practices to manage it. The project progressed well to engage a network of growers and Natural Resource Management (NRM) facilitators for a lasting contribution that will help growers assess how future climate scenarios may impact on their businesses and profitability, and to develop their own farm strategies to respond to climate variability. The project ran a series of field activities and workshops supported by bio-economic analyses to explore climate change in each district, established 10 trials to assess greenhouse gas emissions for suggested adaptation options and conducted paired soil tests to compare soil carbon levels across more than 150 farms.

Field trials showed that there is good potential to reduce daily greenhouse gas emissions using legumes and grass/legume pastures to supply nitrogen to crops, and by using nitrogen fertilisers with inhibitors to slow down the supply of nitrate nitrogen to the soil. On-farm tests showed a big decline in soil carbon under crops and the potential of pasture phases to rebuild soil carbon and soil nutrients. These activities helped build participants' capacity to manage future climate variability and change. Evaluations show that helping growers understand the processes of atmospheric warming, acknowledging the good and the bad of climate change and analysing future scenarios 'struck a chord' with them. Most participants (110 growers) applied what they learnt to develop a strategy to manage climate variability and change on their own farms. Participants' key learnings were:

For improved knowledge:

1. Soil carbon and what it does in mixed farming systems
2. How management/practices affect soil carbon levels
3. How to reduce nitrous oxide emissions
4. Nitrous oxide and why it is important
5. Climate change and variability

For improved skills:

1. Better manage soil organic carbon on farm
2. Consider future climate scenarios in farming decisions
3. Increase the sustainability of practices

Major achievements
Understanding climate change and its implications for local growers

Participatory workshops and bio-economic analyses helped growers and scientists to better understand the processes of climate change, how greenhouse gases contribute to atmospheric warming, historical climate trends across the region, projected climate scenarios and the likely impacts on local farming systems. They also helped participating growers develop strategies for managing possible climate scenarios on their own farms. Ten basic strategies were used, with many growers employing more than one strategy (totals >100%):

1) Ignore climate change ... I don't believe it (3%)
2) Wait and see if climate change is 'real', a 'fad' or 'fake' (5%)
3) Continue to manage climate variability (15%)
4) Keep up to date with climate change policy and information before making decision (26%)
5) Accept and adapt to climate change and variability (15%)
6) Keep up to date with agricultural research ... and so do the best job I can (33%)
7) Manage risk and diversify enterprises and options (44%)
8) Focus on economic returns (13%)
9) Focus on mitigation (7%)
10) Improve specific aspects of current crop and pasture agronomy on my farm (80%)

These strategies confirm that while many growers have a healthy cynicism about climate change, only a small proportion of managers are prepared to simply dismiss or ignore it. Others will continue to manage climate variability and at the very least watch what happens, keep up with new technological advances and implement the practices they know will improve their current enterprises.

Assessing and understanding nitrous oxide emissions for current and future practices

Ten trials were established at key sites across a gradient of rainfall and inputs to assess ways to minimise nitrous oxide emissions. Trials focused on two major practices: a) ley forage pasture systems with forage legume and grass and b) more efficient nitrogen fertiliser rates and formulations (e.g. slow release). These systems are practical adaptation options and provide a range of soil carbon and nitrogen levels that were expected to affect nitrous oxide emissions. The negotiated data collection protocols for static chambers helped the project collect excellent data. Highlights of these results include:

1. Using leys and forage legumes for an organic nitrogen supply to crops produced lower daily nitrous oxide emissions than nitrogen fertiliser. Fertiliser use after pasture led to very high losses due to high available nitrate and labile carbon. While ley pastures are a promising adaptation option with good mitigation potential, these results mean growers and their advisers must manage their nitrogen applications carefully to avoid losses from the improved soil carbon status.
2. Prolonged and very wet conditions (from the devastating floods of 2011) resulted in surprisingly high methane losses from soils.
3. Increasing rates of nitrogen fertiliser led to higher relative nitrous oxide losses, which is to be expected with higher levels of nitrate available for denitrification and loss. However, the scale of nitrous oxide loss

varied greatly with conditions. For example, the nitrous oxide fluxes were 10 times higher at Tamworth than at Pine Ridge;

4. Split applications and formulations with inhibitors (Entec®, 'Green' urea) reduced daily nitrous oxide losses by up to 90%. The effects were most dramatic in summer crops and later in the winter season. This trend is consistent across trials and is encouraging. Agrotain® and Entec® urea with a nitrification inhibitor both reduced nitrous oxide fluxes enough to encourage further agronomic and economic evaluation for dryland cereal production across a range of seasonal conditions. Entec® was the standout performer at Colonsay in southern Queensland, where they were both used.
5. Total treatment losses over a full cropping season are unknown and require automated chambers to assess if legumes do reduce total losses or distribute smaller losses over a longer period.

Assessing and understanding soil organic carbon levels under different land use and farming practices

A series of more than 100 paired-site soil tests was used to compare soil organic carbon levels across a range of land uses and practices on commercial farms. Activities were conducted with existing groups such as Landcare and sub-catchment planning groups that had registered their interest in soil organic matter. Each participant nominated one paired-site comparison. The project team stressed the importance of each pair being the same soil type so the comparison would highlight the impact of past land use and farming practice. Paddock histories were used to classify each paired site into land-use and management groups for comparison. The project team then helped people understand soil organic carbon and its processes, worked with the groups to ensure they understood the results of their own paired tests, and reviewed results across all groups to see how practices affected current soil carbon levels in the region. The key findings were:

1. Cropping has a dramatic impact and reduces soil organic carbon over a long period. This was expected, as the introduction of a fallowing system normally results in a loss of total dry matter production each year but a natural system with established perennial plants does not.
2. Many agronomic practices (e.g. zero tillage, forage crops) have minor impacts on total organic carbon levels. The paired sites used in this project showed no measurable difference in total soil organic matter between zero tillage and conventional tillage systems, nor between long-term grain, forage or fibre (e.g. cotton) cropping systems.
3. Pasture on old crop land has great potential to rebuild soil organic carbon and nutrients for future grain production. Consequently, there is great potential to improve productivity and soil carbon sequestration by establishing persistent pasture legumes as a component of the vast areas of sown pastures in Queensland and northern New South Wales.
4. Pasture production and carbon sequestration is variable and depends on nutrients (especially phosphorous) remaining after the cropping phase. If phosphorus is too depleted to grow good legumes, then grass growth and production will be severely limited by a lack of available nitrogen (commonly recognised as pasture rundown).
5. Comparisons between native pastures and more productive sown pastures confirmed that the greater dry matter production of sown pastures does have potential to provide small increases in soil organic carbon.

Conclusion

These achievements and the continuing demand for project activities, especially for further soil testing to assess soil carbon levels and implement practices to improve soil carbon, are strong evidence of growers' commitment to develop practical adaptations for sustainable and profitable production across the region. This commitment augurs well for future RD&E on practices to build soil organic matter and carbon and reduce nitrous oxide emissions for growers across the region.

Other Research

Future research and development opportunities:

1. Legume and grass/legume pastures need to be further studied to assess whether or not the 'whole season' nitrous oxide and denitrification losses from nitrogen generated from pastures are smaller than losses

from traditional fertiliser treatments. Daily losses are lower but may continue for extended periods as pastures supply nitrogen and carbon over a longer period than a rapid injection of fertiliser. This work will require detailed trials with automated chambers.

2. The use and value of nitrogen fertiliser formulations with inhibitors (e.g. Agrotain® and Entec®) deserve further assessment for their potential to reduce emissions but maintain production. This work needs to include comparisons on placement (on the soil surface or incorporated) in crop and pasture settings. While Entec® looks most promising for use in cropping, Agrotain® may have a role in emissions from pastures as surface applications of nitrogen to pastures across northern Australia become more common in the fight against nitrogen deficiency and sown pasture rundown.
3. Regional carbon comparisons on farms. Continued support is needed to help growers understand how soil carbon works and how to best manage it on their farms. The current project has shown the potential but has only scratched the surface of the need and demand. Continued engagement and region-wide on-farm assessment will not only help growers and their advisers, but complement more detailed research efforts in a cost effective way that will provide great baseline data for the participating regions and the land use/ practices that are monitored. This project supported assessments that growers were interested in. However, any future effort in this area must take a more strategic approach and target specific land use and practices for which information is needed for local decisions. For example, data from highly productive grass/legume pastures versus rundown grass only pastures will be invaluable across northern Australia.
4. Long-term economic assessments of different industries under future climate scenarios. Cropping is currently considered more profitable than pastures and beef production across Queensland but research suggests this balance may change once cropping has to replace the nutrients it is removing from once fertile soils. If continued cropping requires an additional $100/ha to replace/maintain nutrients, then pastures and beef production may be more profitable and sustainable than cropping on many soils. Similarly, the loss of long-term production in pastures established on degraded cropping land that is deficient in nutrients such as phosphorus, sulphur and potassium must be assessed and addressed by the grains and beef industries, as it affects both of them and may result in low levels of production for generations if not addressed. This is a major policy issue for sustainability across the mixed farming areas of Queensland and northern New South Wales.