Modelling profitable and sustainable farming systems in Central Queensland

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Abstract

Central Queensland's dryland farming systems are subject to high levels of climatic variability, are seen as being relatively risky and also suffering falling profitability due (in part) to the rapid decline of nutrient content and physical structure of soils. This suggests that many farming practices in Central Queensland are not sustainable.

A multi agency project that uses participatory on-farm research and development processes has been addressing the core issues that contribute to more sustainable and profitable farming systems in Central Queensland. A component of this research has been the enhancement of farming systems knowledge through combining relevant whole farm models with the biological model APSIM developed by the Agricultural Production Systems Research Unit (APSRU).

The result of this simplified bio-economic modelling is that the profitability and sustainability of a range of farming systems has been simulated and evaluated over time and under varying environmental conditions.

The suitability of this approach as a component of farming systems research aimed at changing farming practices is discussed.

Key words: Whole farm economics, APSIM, crop modelling, climate variability, farming systems research.

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Introduction

Sustainable Farming Systems for Central Queensland (DAQ382) is a multi agency project that seeks to identify and develop sustainable farming practices in Central Queensland. It is one of three major Grains Research and Development Corporation (GRDC) projects set up to address the issue of sustainability of farming systems in the northeastern grain belt of Australia.

"The project is based on the premise that accumulation and integration of knowledge and management skills required by producers to implement successful farming systems are best achieved through a process of action learning". (Doughton et al 1996)

The project can therefore be characterised as using a *farming systems research* approach as outlined by Dillon and Anderson (1984) and reviewed by Petheram and Clark (1998).

The Central Queensland Sustainable Farming Systems Project (CQSFSP) is notable amongst other similar farming systems projects in that both a systems modeller and agricultural economist have been fully employed by the project, along with more than twenty other scientific and extension staff, to progress the aims of the project.

This paper will briefly discuss the background and structure of the project. Then the processes used to integrate the biological model with whole farm budgets plus the outcomes of this process will be discussed. Examples of the outputs of this process are provided in Appendix 1.

Some comment will also be made concerning the interaction of the economics-modelling component with other components of the project. A review of the role and activities of a combined farm management and biological modelling component within farming systems research projects in the future is contained in Appendix 2.

Project Background

Central Queensland is a diverse agricultural region located on the tropic of Capricorn. It contains approximately 26% of Queenslands' cropped lands and contributes about 25% of Queensland beef production. The summer dominant rainfall is highly variable and has fewer rainfall events when compared with the more temperate cropping regions of Australia. This provides a very risky environment for dryland cropping.

Although dryland agriculture has been practiced for more than one hundred years in the region, the vast majority of the land currently cultivated has been developed within the past forty years with a significant amount continuously cultivated for less than twenty years. Cultivation soils are predominately cracking clays that had high fertility when initially cleared. Large expansions in the area under cultivation occurred during the beef industry recession of the 1970s and again during a migration of skilled dryland farmers from southern states during the 1980s.

Most of the dryland farming businesses established during the major phases of development enjoyed a significant and real growth in the value of their investment during the years immediately after both development phases. This real increase in capital values together with the size and relative efficiency of the farming businesses generated a large number of very successful dryland farming enterprises.

The high interest rates of the late 1980s, severe droughts of the early 1990s together with the continuing decline in the terms of trade for broadacre agricultural industries have severely tested farm profitability in more recent times.

Other, more subtle forces have also been modifying the profitability of dryland farming systems. Although Central Queensland is the most recently developed cropping region of Queensland, it also displays the most dramatic decline in nitrogen fertility. (Doughton et al 1996) "Grain farming has relied on reserves of inherent fertility which are being exhausted by ongoing cropping. Associated with in situ chemical and physical degradation of soils has been extensive soil erosion causing further degradation of the land resource base. There is a growing awareness that many grain farming practices in CQ are not sustainable." (Doughton et al 1996)

Grain farmers can be faced with the multiple predicaments of highly variable rainfall, limited soil water storage capacity, declining soil fertility and unreliable cropping returns.

The early participatory process distilled the aims and priorities of the project down to a few key issues, two of which were better water management and better nitrogen management. The key technologies that were to be integrated into existing farming systems to address these issues were listed as:

- Controlled traffic farming
- Minimum or zero till farming
- Opportunity cropping
- The introduction of legumes.

Project participants believed that activities focussed on these technologies and carried out by the farmer groups would be the best way to develop sustainable farming systems for Central Queensland.

CQSFSP modelling and economics methods and process

The core processes of the CQSFSP modelling and economics team centred on incorporating data from:

- biological simulation models,
- on farm trials and,
- research station experiments

into the various forms of farm management budgets to provide insights into the nature of current and possible dryland farming systems in Central Queensland. The farm budgets were structured to represent farm businesses relevant to the general district of the farmer groups.

Biological modelling process

Much of the modelling of long-term production systems was completed with the APSIM model (McCown et al 1995). This model is comprehensive in the range of soil and crop processes that can be simulated. Simulations using long-term daily weather records can be carried out for single crops or rotations involving up to 20 crops or fallow periods. Crop, soil water, nitrogen, crop residue and tillage inputs can be manipulated in a flexible fashion. The crop physiological data, soil water and nutrient data can be examined separately. This facilitates understanding and debugging of the simulations.

APSIM is a daily time step model that mathematically reproduces the physical processes taking place in a cropping system. This calculation of daily outcomes within the model allows measurements from a modelled cropping system to be collected on a time basis and/or event basis. APSIM can be run for any number of days up to the total length of suitable climate records available to the model.

The ability of APSIM to give dates for events, time spans between events, to measure the impacts of production process such as soil loss, soil N fluctuations and water runoff for each simulated farming systems is critical. When this information is combined with representative whole farm investment models the economic effects shown can be related to specific sequences of climatic events, soil states, or states of the farming system. The outcomes of the simulation depend upon a fairly transparent set of economic and biological relationships that can be identified, discussed and interpreted.

A major strength of APSIM is its ability to reflect accurately the impact of the variable climate of CQ on different farming systems. This is critical for a region dominated by low tillage, opportunity cropping farming systems.

Note: Recent research into the water balance of the suitable cropping soils in CQ (Carrol et al 1993) reveals that low fallow efficiencies lead to crops relying upon "the larger, less frequent, and often intense rainfall events" (Spackman and Garside 1995). Farm managers have adapted cropping practices so that it is now more likely that crops will be sown when suitable soil water conditions are available and less likely that land will be fallowed to store water for a particular crop sowing period. This approach is commonly referred to as opportunity cropping. Set cropping patterns or rotations can rarely be followed under the climatic variability experienced in CQ.

There are some severe limitations, however, to this modelling approach. APSIM has to be configured specifically and precisely for each location. This configuration includes a set of daily weather records and a detailed characterisation of the soil or soils available at each site. APSIM also "plants" crops on a single day with an even plant establishment plus optimal plant population and spacing. These crops are then grown free of weed and insect competition, without suffering harvest losses or frost damage. The crops and rotations modelled within APSIM respond only to crop sequence, soil and weather influences. They do not respond over time to changing price relationships, the perceived riskiness of alternate crops or the timeliness of alternate farming systems.

APSIM is therefore a tool suitable for the exploration of some problems and not others.

The initial use of APSIM within the CQSFSP was to examine yield and protein outcomes from dryland monoculture sorghum, monoculture wheat and opportunity cropping of sorghum and wheat under zero till farming conditions. Representative farms for the Dawson Callide and Central Highlands were modelled at Biloela and Capella respectively.

The example soils had plant available water capacity (PAWC) of either 100mm or 150mm for the Biloela property or 90mm, 120mm, and 150mm for the Capella property. Soil carbon and nitrogen levels were set to simulate soils of low, medium and high fertility at the beginning of each time period modelled.

Simulated N fertiliser rates were 0, 50, 100 kg N/ha and a tactical N rate determined on the basis of a 1:1 ratio of soil water (in mm) and available soil nitrate (in kg N/ha) at sowing. The tactical N fertiliser regime was based on the work of Dalal et al (1997).

Economic modelling process

The outputs of APSIM, farm trials and scientific research have been incorporated into farm management budgets in two main ways. Firstly the outputs were arranged in time sequence and used to construct relatively simple cash flow and investment budgets. Secondly the outputs were arranged as probability distributions or response functions and used again to construct simple farm budgets that had probability distributions as outcomes.

A structure for farm management budgets similar to that recommended by Ferris and Malcolm (1999) and Makeham and Malcolm (1993) was used.

Using the first approach with the output of APSIM allowed the construction of conventional cash flow or investment budgets over any time period (or periods) for which suitable climate data was available. Investment budgets were generally constructed for thirty year time periods to allow for at least one investment cycle for farm plant and equipment.

In this form of modelling, scenarios for different production systems were constructed by combining the discrete sets of grain yields and proteins (that were produced in a time series by APSIM) with relevant whole farm models. Each set of yields relied on the underlying weather, soil, fertiliser, crop and other management inputs specified in APSIM. Scenarios were then compared to discern the critical factors that were driving the performance of each modelled farm business.

Using the second approach relied upon the ability of APSIM to calculate precisely inputs and outputs over time and under a variety of seasonal conditions. This allowed response functions or probability distributions to be built for crop response to such things as variable fertiliser inputs, variable soil fertility, the phases of the Southern Oscillation Index (SOI), differing crop variety or any other combination of the production variables that can be simulated in APSIM.

The distributions were then used in conjunction with farm budgets ranging from simple gross margins through to whole farm investment models similar in complexity to RISKFARM (Thompson 1994) to construct distributions of outcomes. In this form of budgeting the variables that decided the range of outcomes for the budget were represented as random variables with defined probability distributions. Correlations between variables were also represented. Incorporating suitable probability distributions into the model indicated the probability of exceeding (or not exceeding) any value or target. The variability of outcomes was also easily graphically represented.

A sensitivity analysis framework, as suggested by Pannell (1996), was often applied to test the relationships between parameters and the break-even levels for parameters.

The spreadsheet add-on @RISK was used to facilitate this probability based budgeting process. Overall, a combination of APSIM specified production distributions, subjectively nominated price distributions and @RISK were used to construct static or "steady state" whole farm budgets as well as multi-period investment models.

Output from this form of modelling has been presented in probabilistic terms and does not seek to provide optimal solutions to production or other problems. Used in conjunction with the scenario modelling approach, the probabilistic framework of this approach allows the incorporation of additional sources of risk that are not accounted for in the APSIM model.

Finally, the input/output data from the trials constructed in farm paddocks was compiled into gross margins or representative whole farm budgets and compared to the results of the modelling process.

Importantly, the flexibility of the farm management budgeting structure allowed the results of the modelling, the paddock trial data and the research outputs to be presented in a similar format for discussion.

Outcomes of the approach taken

Biological modelling outcomes

APSIM produced satisfactory yield and protein distributions for sorghum and wheat. The soil nitrogen run down curves and crop rotation scenarios were credible. Tactical N fertiliser application rates were automatically calculated by the model and hence trends in N requirement over time could be traced.

Economic modelling outcomes

Basing a farm investment budget on the output of a biological model means that much of the complexity of farm businesses, their decision making processes and risks will be presented in a very simple form. This allows easy identification of the effect of production variables on farm output but not much else.

The conditions under which APSIM produces a crop (without weeds, insects, hail, wet harvests, with perfect timeliness etc) often creates representative farm businesses significantly more profitable than their real world counterparts. The interpretation of such modelling results has to be careful and considered before conclusions are drawn about what applies in the real world of farming.

For these reasons, the comparison became more about the relative differences between farming systems modelled in APSIM and less about the absolute values for the financial performance of the modelled farm businesses being compared to actual farm businesses.

Some results of the biological and economic modelling process that initially looked plausible and positive relied upon a timeliness of operations or a risk attitude by management that could not be repeated in a real farm business. These outcomes were discounted and, where possible, the APSIM model was reconfigured to better reflect the timeliness available to better farm managers.

On a number of occasions the modelling process produced economic results that appeared to be counter-intuitive. Further investigation into the cause and effect relationships provided some new ways of thinking about the nature of dryland farming systems in Central Queensland. That is, the modelling process on some occasions produced a new understanding that may have not been obtained by more conventional methods of investigation.

To date, the modelling activities have concentrated on identifying the main production drivers of dryland farming systems in Central Queensland (Appendix 1). The technical nature of the CQSFSP and the close interface with industry required this focus.

Conclusion

The overall modelling process was directed at providing a greater depth of knowledge regarding the two main themes of the project, i.e. sustainable and profitable farming systems in a highly variable subtropical environment. It also tried to place the results of the on-farm trials into the same context.

Our approach aimed to aid discussions and join in the learning process. We used a whole farm budgeting structure as we felt this was the best way for the discussions between farm managers, researchers and extension workers to focus on the factors critical to the success of CQ farming systems.

While other forms of optimising and dynamic budgeting approaches are available, the nature of the output from APSIM, the ease of its incorporation into a traditional whole farm budgeting structure and the need to present the results in a transparent form to project participants encouraged the approach taken.

The benefits of this extensive communication across disciplines using a background structure based on whole farm modelling have been reviewed and endorsed elsewhere. (Pannell 1996)

Pannell (1996) records that a large benefit or impact of this approach is with non-farm participants of projects or departments of agriculture. Our experience also is that providing insights for the scientific and extension community about the effect of various strategies on farm businesses can be very valuable to progressing the outcomes of any farming systems project.

Presenting modelling outcomes to farm managers has proven to be more variable in impact. The relating of probabilistic outcomes for farm investments over time has mostly had little impact because of the "not specific enough" nature of the outcomes.

Providing discrete scenarios that use climate sequences to model a few decadal outcomes for a representative farm business has proven to stimulate more useful discussion even though all outcomes are not fully represented.

Recent experience with a south east Queensland based farming systems project that was introduced to the scenario modelling process showed that discussions quickly shift from rotations, yields and fertiliser rates to aspects of investments, returns and risks relating to the farming systems under consideration.

Overall, the combination of model outputs, paddock trial results and project participant experience through an iterative modelling process has proved to be a considerable stimulus to learning within the CQSFSP. The modelling has tended to broaden the view of participants and has provided a context within which the value of new knowledge can be considered. The ability of APSIM to model accurately the biological dynamics of a chosen farming system over a set time period has been central to the modelling process.

Although there is no ability to identify optimal responses to changes in farming systems using this approach, basing the farm management budgets on "best bet" farming systems described by experienced extension workers and farm managers hopefully overcomes most of this deficiency.

The successful combination of a whole farm economic approach, biological modelling and an action learning process within a farming systems project relies upon having suitably skilled project participants available who can commit a considerable amount of time to the process. Failure to have either the farm management economic or biological modelling skills readily available would significantly reduce the outcomes available to the project.

Recent reviews of the CQSFSP by GRDC staff and others have strongly supported the extension to other farming systems projects of the combination of biological modelling and farm management economics delivered by CQSFSP staff. This cannot happen without a strong commitment by all participants to the process.

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APPENDIX 1

Example outputs of the processes employed

1. *Modelling cropping system response by season*

Why the work was done

Theodore SFSP group data for summer crops of the 2000/01 season was used to run the crop model APSIM (via the APSFRONT interface).

The purpose of this exercise was two-fold:

- Firstly it would 'value-add' to the data collected by the Project and individual growers by giving insights into soil water, nitrate levels and plant growth throughout the summer season.

- Secondly it was designed to test the ability of model to mimic crop production in sorghum and mungbean under CQ conditions.

How the work was done

Data from one SFSP site with 4 N treatments (0N, 30 N, 45 N, 60 N) on sorghum and another data set for a SFSP site growing mungbean for the 2000/01 season was used to run APSFRONT. In addition 7 sorghum paddocks monitored by growers during the summer of 2000/01 using the TopCrop monitoring process were modelled.

Soil water and soil nitrate files were created and crop agronomy and management details were used to run the model. The soil data required for each site included starting soil water, starting nitrate levels, effective rooting depth, pH, bulk density and organic carbon. In the 'TopCrop paddocks' the initial soil water was not known. This was estimated using fallow rainfall records from nearby recording stations and the computer program 'HowWet'. Not all soil characteristics were known for each TopCrop site. Hence some soil information was estimated from surrounding sites.

The results were presented to the group in an end-of-season feedback meeting. Part of this report-back process involved a group discussion on the model outputs and drawing linkages between starting conditions, crop management and crop performance.

What happened?

Table 1 Actual versus modelled yield for crops grown in the 2000/2001 summer season at Theodore, Central Queensland

Treatment	Yield (actual)* t ha^{-1}	Yield (modelled) t ha-1	Comments
Sorghum 0 N	2.39	2.56	
Sorghum 30 N	3.36	3.52	
Sorghum 45 N	3.44	3.69	
Sorghum 60 N	3.34	3.69	
Mungbean	0.66	0.96	Harvest losses not accounted for in modelled data
Sorghum TopCrop 1	3.29	3.76	
Sorghum TopCrop 2	1.57	3.05	Low in-crop yield due to summer grass infestation
Sorghum TopCrop 3	3.20	3.53	
Sorghum TopCrop 4	1.92	3.17	Low in-crop yield due to pigs, birds and crop lodging
Sorghum TopCrop 5	2.91	2.01	Modelled crop highly moisture stressed - sample measurements of starting soil water may not have been indicative of the whole paddock
Sorghum TopCrop 6	2.07	3.50	Soil data estimated from surrounding site information which may have contributed to low crop yield relative to modelled data
Sorghum TopCrop 7	2.24	3.24	Soil data estimated from surrounding site information which may have contributed to low crop yield relative to modelled data

* Yield quoted at 0% moisture

Generally the modelled and actual paddock yields were well correlated (Figure 1). Model yields tended to be greater than paddock yields as the model produces 'optimal' yield (i.e. the impact of pest, disease, weeds and harvest losses is not simulated). In some cases factors such as weed infestation and feral animals significantly reduced paddock yields and the model was unable to take this into account. For one paddock we were unable to explain why the model under-predicted yield. The model may have been highly sensitive to moisture stress and subsequent relief from that stress during grain filling (Hammer pers. comm.).

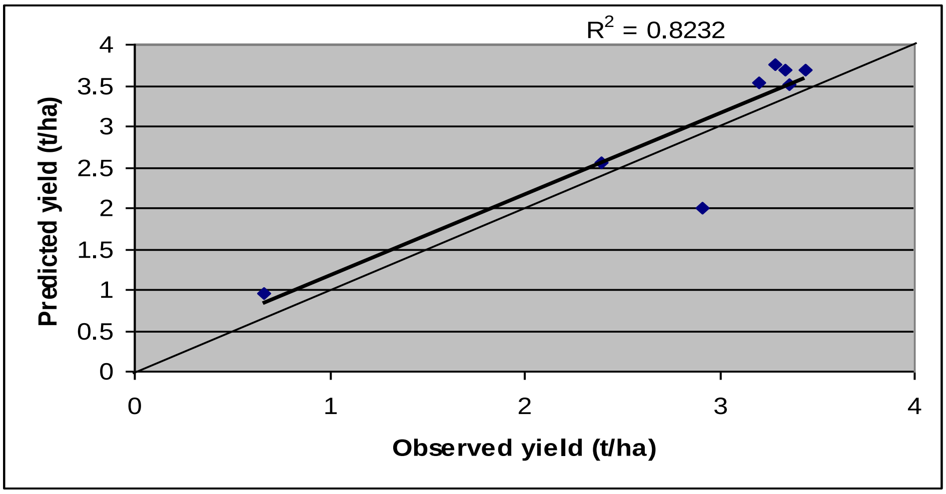


Figure 1 Correlation of observed and modelled yields for CQSFSP summer crops grown at Theodore, Central Queensland during the summer of 2000/2001

As a means of providing further insights into what was happening in the monitored paddocks during the season soil water, soil nitrate and plant growth and production were reported on a daily basis in the modelled crops (Figure 2). This provided the basis for linking crop performance with starting conditions, seasonal conditions and management inputs.

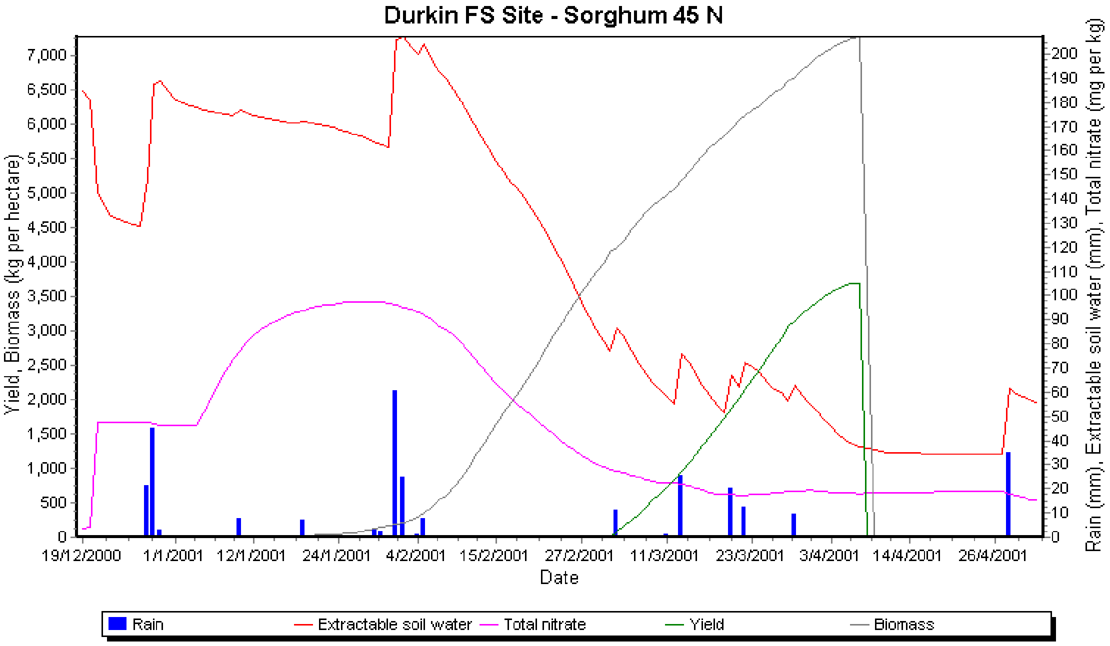


Figure 2 Soil water, soil nitrate, plant growth and production as reported by APSIM on a daily basis for a modelled crop at Theodore, CQ

What does it mean?

This type of modelling exercise can give us insights into a season and crop performance. We now have greater confidence that the model can mimic field conditions provided soil measurements and other inputs reflect the in-field conditions.

It can be difficult to get acceptable agreement between modelled data and paddock yields or to know the reasons for discrepancies between these yields when soil data has been assumed from surrounding areas rather than measured directly for a particular paddock.

2. *Modelling farming system response to climate*

Why was the work done

The purpose of this exercise was to consider the impact of climate on the economic and financial outcomes of alternate farming systems over discrete periods of the 100 years of available weather data for the Capella district.

How was the work done?

Capella soil and climate data files were run for eight, thirty-year climate periods in APSIM with the model output applied to a whole farm investment model that represented a typical farm business for the district. Soil water and soil nitrate levels were calculated on a daily basis within APSIM. Cash flows were calculated on an annual basis and depended upon the cropping events modelled during each cropping period. Investment returns were calculated for each thirty-year period and treatment modelled.

What happened?

Figure 3 shows one example of the cumulative cash flows for two representative farm businesses modelled by APSIM. They were established in the climate year of 1970 and received costs and returns from 1970 to 1999 based on year 1999 costs and returns. The 2000ha farms were modelled to either plant sorghum crops alone or to opportunity crop sorghum and wheat as weather conditions allowed.

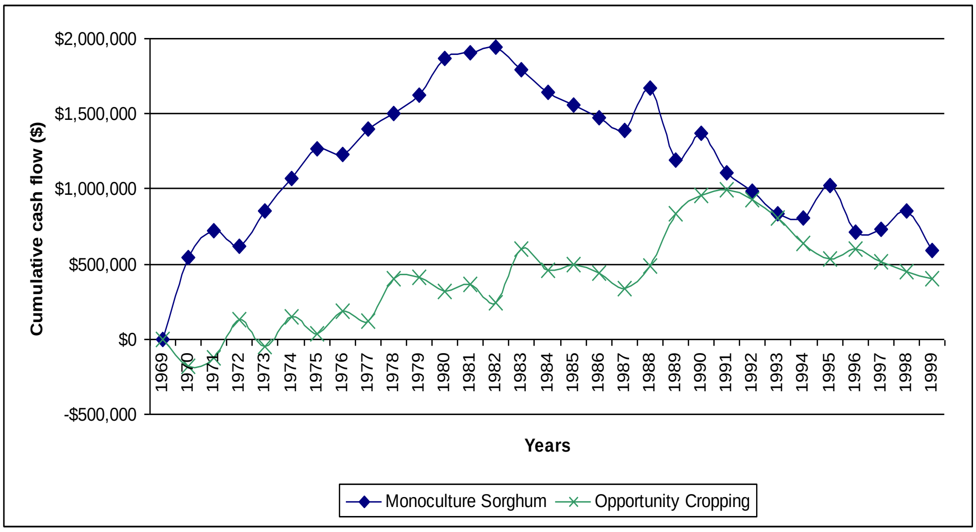


Figure 3 Cumulative cash flows for modelled farm businesses at Capella growing either monoculture sorghum or opportunity cropped sorghum and wheat on an average depth soil with medium soil nitrates. Fertiliser applied tactically.

The cash flows of the modelled farm business follow very closely the climate trends for Capella for this period due to prices being held constant at 1999 levels for the entire period from 1970 to 1999.

From figure 3 it can be seen that including winter crops in the farming program during the 1970's would have reduced the potential cash surplus of the business by about $1.5 million compared to the specialist sorghum grower. This was obviously a summer rainfall dominant period even though the five years to 1975 had winter rainfall 250mm above average.

Failing to include winter crops from the middle 1980's up until the early 1990's cost the sorghum grower about $1 million (Figure 3). The five years to 1985 had about 590mm more winter rainfall than average and summer rainfall about 250mm below average. This is considered to be the wettest winter rainfall period recorded since the early 1890's. At the end of this period both businesses were in a financially similar position. From then on the dry years after 1990 caused both businesses to lose about $500,000 up until 1999.

Discussions with local farmers reveal a similar pattern of cash flows for their farm businesses, especially during the 1990's, although the actual market price for wheat that prevailed during the early to middle 1980's was generally greater in real terms than the price used in the analysis and most similar actual farm businesses would not have incurred the extra cost of fertiliser required to grow the modelled crops.

Figure 4 shows the complete set of investment analyses starting in 1900. Each bar on the graph represents the investment return for a thirty-year climate period beginning in the years shown across the x-axis of the graph.

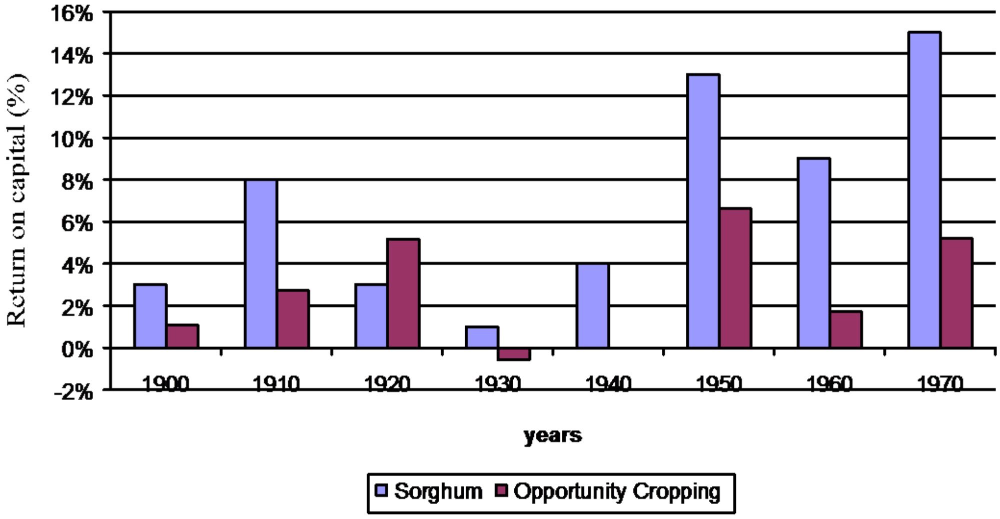


Figure 4 Thirty year investment returns for modelled farm businesses at Capella growing either monoculture sorghum or opportunity cropped sorghum and wheat on an average depth soil with medium soil nitrates. Fertiliser applied tactically.

When the individual thirty-year cash flows are converted through investment analysis techniques to returns on capital calculated over the life of the investment, it can be seen that sorghum (or summer only) cropping out preforms opportunity cropping that includes the taking of winter cropping opportunities as they arise. (Figure 4)

What does it mean?

The Capella district has only been farmed since the late 1960's. The zero till technology modelled has only recently been incorporated on some farms in the district. The recommended "best bet" farming system is currently an opportunity cropping low tillage farming system that includes taking winter opportunities as they occur. On the basis of the modelled outcomes it appears that the recommended best bet farming system may be underestimating the summer dominant nature of the climate in the Capella district over the longer term and could restrict potential farm profitability accordingly.

The modelling suggests that taking a good winter opportunity has a good chance of producing a reasonable crop but will mostly preclude growing a crop in the following summer. Once this summer opportunity is missed, there is a one in three chance that a planting opportunity will not be received in the next winter. Over time this inability to return rapidly to the more reliable summer crop and the possibility of a long fallow seems to reduce long term farm profitability in the more summer dominant rainfall districts of the region.

3. Modelling the potential of alternate cereal crops

Why was the work done

Sorghum and wheat are commonly seen as alternate crops for CQ dryland farming systems. Wheat is often preferred due to its low in-crop weed pressure, its ease of establishment, its lower growing costs, its greater suitability for the available planting equipment and its history of higher returns relative to sorghum. Sorghum can also continue as a weed in paddocks after harvest and may not provide the same level of residual soil cover as wheat.

Falling levels of soil nitrate in many Central Queensland paddocks now require both crops to be fertilised for optimal returns. The general decline in premiums for high protein wheat and the erratic winter seasons of recent times have also thrown a shadow over the returns available from wheat growing.

How was the work done?

Wheat and Sorghum gross margins were extracted from APSIM runs based on a Capella weather data set and a typical shallow open downs soil for the district that had been farmed for approximately 30 years. The gross margins were presented as cumulative probability distributions and compared on the basis of what was the likely range of outcomes if a good planting opportunity were received to establish each crop.

What happened?

Figure 5 shows modelled gross margins for wheat and sorghum that could be achieved over the past 100 years of climate history for Capella using current costs and returns.

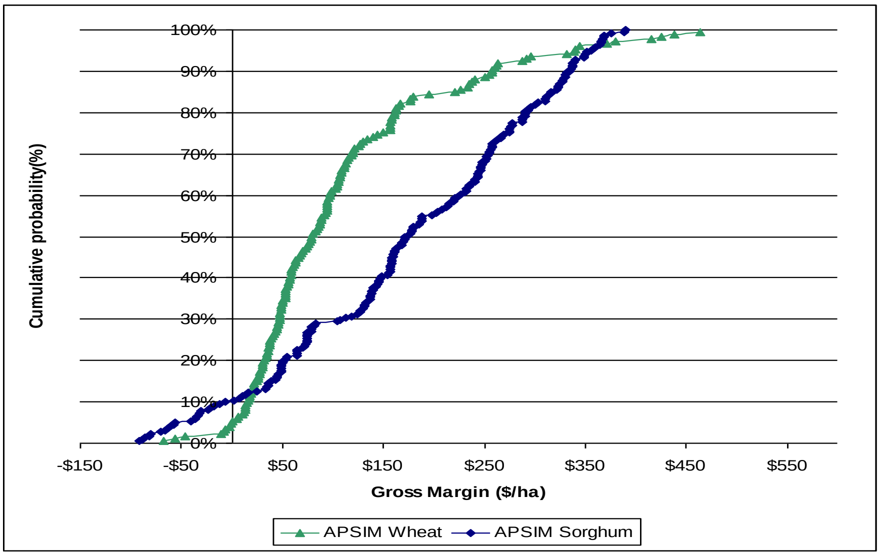


Figure 5 Optimal gross margins for sorghum and wheat on a soil that stores a maximum of 120 mm available water and has medium soil nitrogen at Capella as modelled by APSIM.

The APSIM based gross margins show sorghum clearly outperforming wheat in about 85% of years. The median modelled advantage is about $100 /ha. The local farmer consensus is that "in the paddock" gross margin performance is generally similar over time when suitable planting opportunities are received. Modelling based on the available climate data for Capella indicates that wheat has a 66% chance of getting a favourable planting opportunity against an 85% chance for sorghum.

What does it mean?

The shortcomings of sorghum in the farmers' paddock are mainly due to establishment problems, (which can cause an average 30% yield loss), crop lodging, soil nitrogen run down and harvest losses.

Assessment of the available technology and costs of improving the precision of the sorghum farming system shows no clear choice of technology that can meet the needs of a low tillage sorghum farmer who wants to:

- apply a reasonable amount of N fertiliser at planting,
- have the capacity to efficiently plant a range of crops under most conditions found on local properties and
- do so at a reasonable cost.

Many farm businesses would also be unable to immediately finance the necessary equipment even if it were available. These financial constraints either lead to the suboptimal system that includes wheat growing being maintained or alternate farming systems that do not require high rates of fertiliser N being considered.

4. Modelling the economics of restoring soil fertility with fertiliser N

Why was the work done

The need to rebuild soil fertility is often seen as a prerequisite to achieving a sustainable cropping system. One suggested strategy to restore and maintain fertility at a level that will not constrain crop performance is to apply fertiliser N at a higher rate than it is removed by current cropping activities. In this way soil fertility will be rebuilt over time and crop performance improved. It was estimated that applying 100kg N/crop grown of N fertiliser would be sufficient to restore fertility over time in Central Queensland opportunity cropping systems.

The potential economic effect of this approach was modelled using APSIM runs combined with a gross margin analysis.

How was the work done?

Capella soil and climate data files were run for eight, thirty-year climate periods in APSIM. Soil water and soil nitrate levels were calculated on a daily basis within APSIM to track changes in soil nitrate over time. Gross margins were calculated for each crop grown and included premiums or discounts for grain protein in wheat.

What happened?

Figure 6 shows the expected annual level of available soil nitrate and general trends in available soil nitrate under an opportunity cropping zero till farming system continued for thirty years at Capella as modelled by APSIM. The soil was modelled as having low available soil nitrate at the beginning of each farming sequence, consistent with having been farmed without N fertiliser for about thirty-five to forty years. (This is the case for a considerable portion of the downs farming country around Capella)

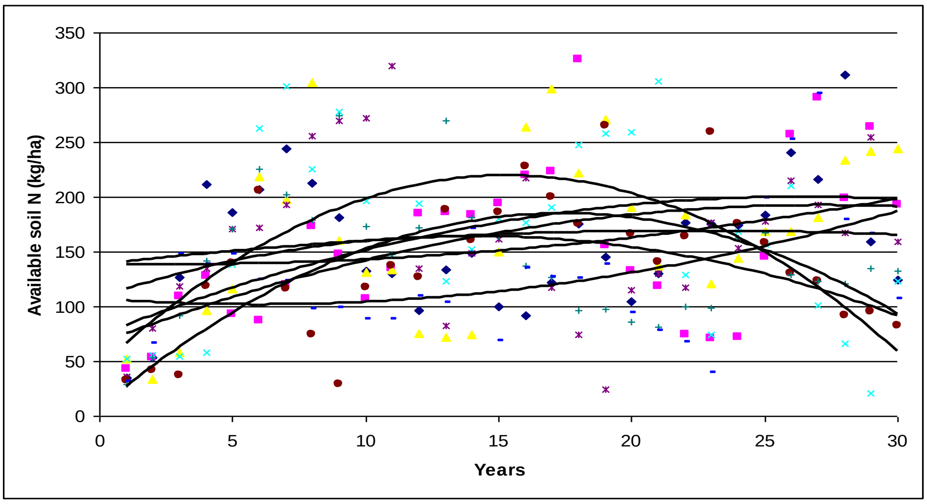


Figure 6 Trends in available soil nitrates under opportunity cropping at Capella on a low N, average PAWC soil with fertiliser N applied at 100kg N/crop grown. Farming systems were modelled for eight overlapping thirty-year climate sequences. Each line represents a thirty-year period.

Over about 60% of climate sequences, APSIM predicted that soil fertility would be at least maintained or improved. In about 40% of sequences, soil fertility climbed then fell or slowly fell (see trend lines Figure 6). In all cropping seasons available soil nitrates would not have limited crop performance.

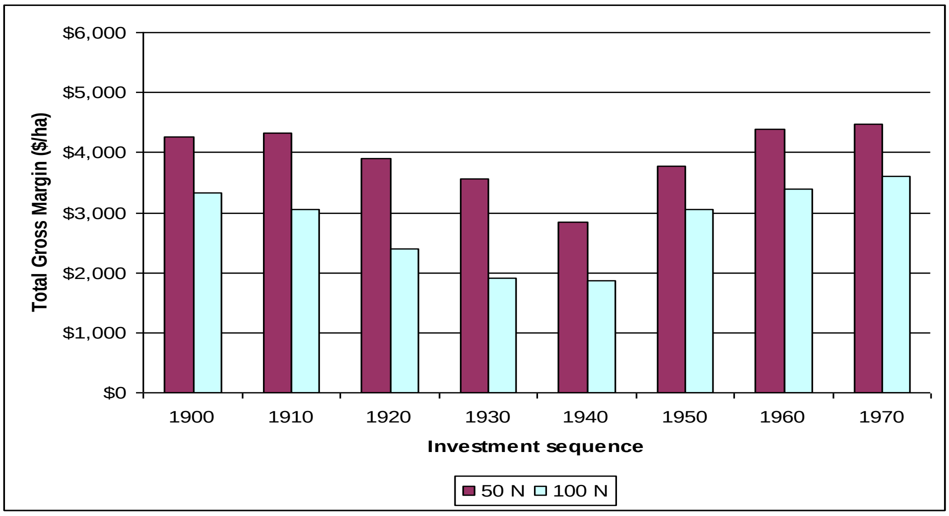


Figure 7 Total gross margins for thirty-year investment sequences of opportunity cropping sorghum and wheat at Capella on a low nitrate, average PAWC soil.

The rate applied to maintain and possibly restore fertility (100 kg N/ha/crop) reduces the total gross margin of the optimal fertiliser strategy (50 kg N/ha/crop) by 20% to 50% over any thirty-year period (Figure 7). This mainly depends upon the sequence of seasons encountered.

What does it mean?

Applying N fertiliser to restore or maintain soil fertility will significantly reduce the overall profitability of a specialist agricultural property in Central Queensland, even when the strategy is only begun after the inherent fertility reserves of the soil are largely exhausted. The optimal strategy of providing less than the median crop demand for N as fertiliser at planting provides a much more profitable farm business but will continue the decline in soil fertility.

5. Modelling climate impact on farm start up

Why was the work done

The purpose of this exercise was to consider the economic impact of a variable climate on the start up phase of a farm investment in the Biloela district.

How was the work done?

Biloela soil and climate data files were run for eight, thirty-year climate periods in APSIM with the model output applied to a whole farm investment model that represented a typical dryland farming business for the district. Cash flows were calculated on an annual basis for each investment sequence and combined into a cumulative cash flow for each thirty-year period. The representative farm business began each investment sequence with 80% equity.

Costs and returns were held constant at 1999 levels during the analysis so that the effect of a variable climate on the representative farm model at current profitability levels could be estimated. The costs were based on a property that applied a zero till controlled traffic farming system to grow crops.

What happened?

The modelled outcomes for a range of crops and cropping systems indicated that the success of the farm business was more affected by the climate received at the time of farm start-up than the cropping system used. Figure 8 shows the cash flows generated by a monoculture wheat business.

Commencing farming during 1900, 1910 or 1940 at Biloela would have led to business failure for the representative farm business. Conversely, starting to farm at 1930 would have led to considerable financial success. Starting a farm business at 1990 in Biloela would also have led to business failure (Data not shown).

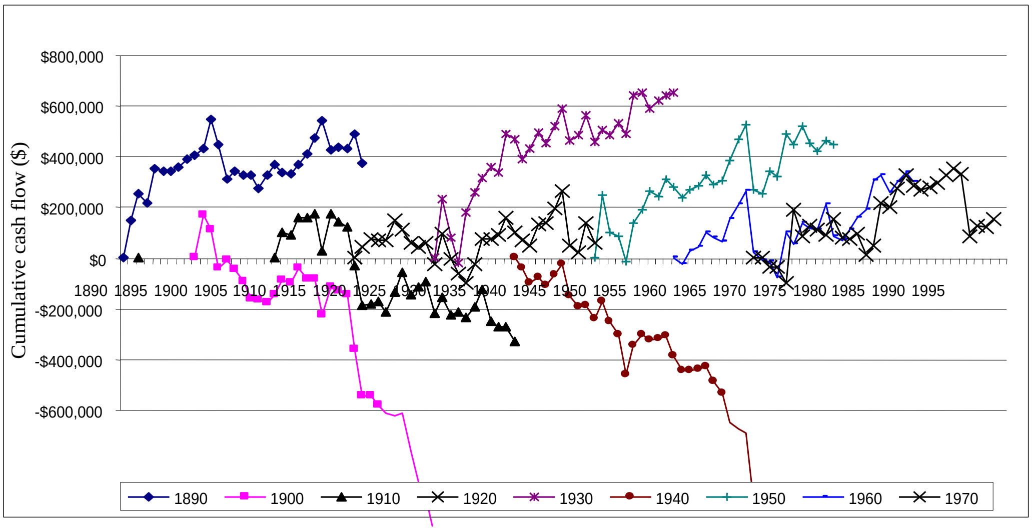


Figure 8 Cash flow by starting decade for monoculture wheat on a moderate nitrogen soil with 158 mm PAWC

What does it mean?

The decade beginning in 1990 is said to be the most difficult decade so far encountered by farmers in Central Queensland. Unfortunately, prior to broad scale dryland agriculture beginning in Central Queensland and since settlement, at least three equally disastrous climate sequences have occurred.

Investors in Central Queensland dryland farming systems must be aware that they will probably encounter climate sequences during the life of the investment that will severely test their financial resilience. The unfortunate circumstance of starting a farming business during one of these difficult climate phases could lead to its failure - depending on the equity position and financial reserves held at the beginning of the investment.

Starting a farm business at other times with sufficient capital, a strong equity and sound management skills should allow the development of a viable farm investment, even at current prices.

6. Modelling cropping frequency

Why was the work done

A number of farm mangers and crop scientists express the view that more frequent cropping in Central Queensland should improve overall farm business performance.

Cropping activities can be made more frequent by planting outside of "normal" planting windows and/or taking double cropping opportunities when they occur. Planting crops on lower levels of stored soil water and lesser rainfall events may also increase cropping frequency.

How was the work done?

APSIM was configured to opportunity crop wheat or sorghum over thirty year investment periods for a representative farm business at Biloela. A series of runs were completed using what are considered to be accepted practice planting rules. Another series were completed using more lenient rules when it came to stored soil water at planting and what constituted a planting rain. The accepted practice planting rules were based on having a ⅔ full soil profile during the planting window and receiving at least 30mm of rain over a four day period.

The yield and protein outcomes of the APSIM modelling runs were applied to representative farm investment models with both total gross margins and investment returns calculated.

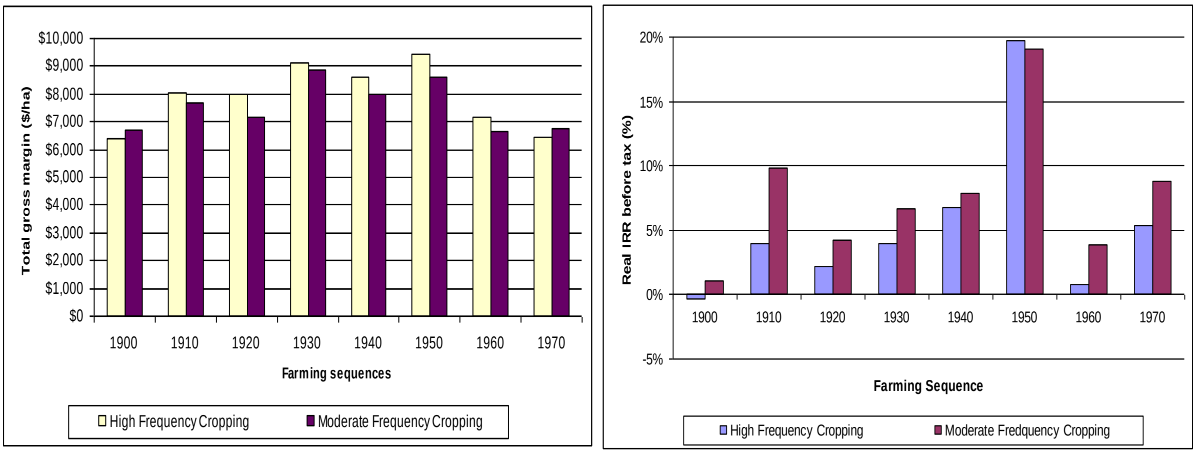
What happened?

Using the more lenient planting rules produced 37 to 45 crops over the thirty-year climate phases. 20% to 35% were winter crops with the remainder being summer crops. Taking the better planting opportunities produced 30 to 36 crops over any investment period with about 30% winter crops.

Figure 9 shows the results of the analysis calculated as either a total gross margin (they only show the crop income and variable crop costs) or investment returns (they include an allowance for machinery use and the labour of the farm owner).

The total gross margin measure (Figure 9(a)) shows that taking the more lenient approach to cropping opportunities seems to out perform taking only the better opportunities. Individual gross margins were about 15% greater on average when the better planting opportunities were taken than those produced by taking the more lenient opportunities.

Taking the more lenient opportunities produced more gross margins in total and therefore a higher gross margin over a thirty-year period.



(a) (b)

Figure 9 Total gross margins (a) and investment returns (b) for opportunity cropping at Biloela on an average nitrate, high PAWC soil.

While the total gross margin favoured more frequent cropping, the investment returns that included the additional labour required to grow extra crops and account for additional machine use, favoured the taking of only the better planting opportunities.

Note that the investment period beginning at 1950 received significantly higher summer and winter rainfalls than any other period. Planting crops on lower stored soil water was not penalised due to the increased likelihood of receiving a follow up rain over this period.

What does it mean?

A farm business that increases cropping intensity through taking the lesser cropping opportunities is only infrequently more successful than one that takes a less aggressive stance on planting crops. This success depends upon receiving suitable follow up rain. Unfortunately this climate sequence has only occurred in one sequence out of the eight possible scenarios tested.

Over the longer term, taking only the better planting opportunities is more likely to produce a more profitable farm business.

The general rule seems to be that successful farm businesses will be the ones that can respond fully and in a timely and precise manner to the better cropping opportunities as they arise. If good opportunities come in rapid succession, they must be taken in rapid succession.

Farm businesses that cannot respond in a timely and precise way will fall behind. This response will largely depend upon the correct management of a low tillage farming system that has access to appropriate precision planting machinery and labour resources when required.

7. *Modelling the effect of varying soil PAWC*

Why was the work done

Central Queensland is characterised by hot summers with intermittent rainfall events and dry, cool winters. This variable and unreliable rainfall seems to require dryland farming to be carried out only on soils that store and make available a reasonable amount of water for crop growth.

Conversely, the low fallow efficiencies of CQ farming conditions means that little of the rain that falls during a fallow is available to the following crop, reducing the benefit of farming a soil with high water storage capacity.

A question often asked is "how important is plant available water capacity (PAWC) to cropping success"? PAWC is a measure of the maximum amount of water that a soil can store and make available for plant growth. The falling soil nitrates of CQ farming soils and the increasing need for fertiliser N add a further dimension to the PAWC question.

Most actual farming soils in Central Queensland are very variable in PAWC across paddocks. Trials carried out at a paddock scale over a few seasons are unlikely to answer questions about the effect of PAWC on cropping.

APSIM, with its ability to precisely characterise soils and apply accurate inputs to crops growing under identical but numerous weather conditions, provides a structure under which questions about PAWC can be investigated.

How was the work done?

Capella soil and climate data files were run for eight, thirty-year climate periods in APSIM. PAWC's of 90mm, 120mm and 150mm were modelled with fertiliser nitrogen applied at fixed rates of zero, 50 or 100 kg N/ha per crop. A tactical application of fertiliser nitrogen was also modelled. The tactical amount of fertiliser applied varied with the relationship of stored water and available soil nitrates at planting. This approach was aimed at optimising fertiliser response.

Starting soil nitrates were set at levels equivalent to the soil having been farmed for forty to fifty years therefore they had a low starting soil nitrate.

Gross margins were calculated for each crop grown and included premiums or discounts for grain protein where applicable. Total gross margins for each thirty-year run we calculated and then averaged across the eight overlapping climate periods.

What happened?

Figure 10 shows that the most economic fertiliser application varies significantly with soil PAWC and that the general profitability of cropping greatly varies with PAWC.

It should be noted that the tactical rate varied with the PAWC of the soil. Hence Figure 10 shows only the 90mm PAWC soil being fertilised at 33 kg N/ha/crop as this was its tactical rate. The 120mm and 150mm PAWC soils both achieved a tactical rate close to 60kg N/ha/annum.

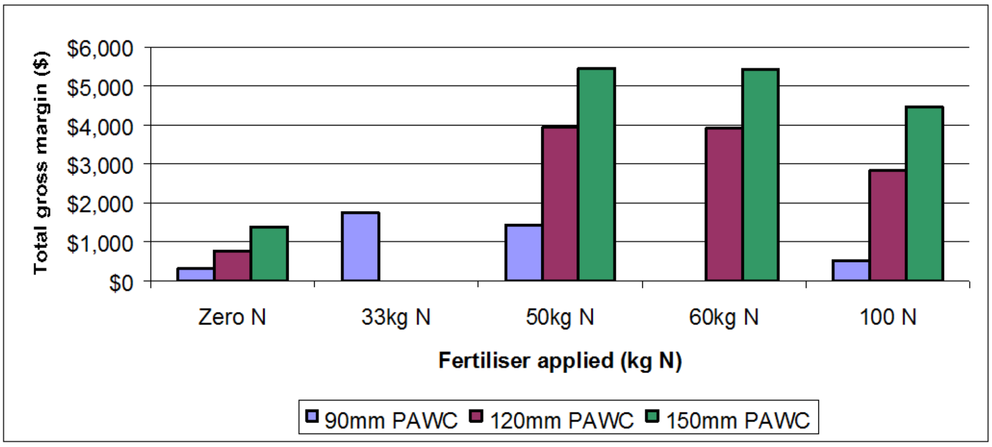


Figure 10 Total gross margins for thirty-year investment periods for varying rates of fertiliser application and soil PAWC at Capella on a low nitrate soil.

A 90mm PAWC soil only requires an average application of about 25 - 35 kg N per crop to produce its most economic response. Applying a similar amount of fertiliser to a soil that is close by with a 30% higher PAWC (i.e. 120mm) may reduce the potential response on this soil by up to $60 per hectare per annum. Patches of soil within the same paddock that have a 60% higher PAWC than the 90mm soil (i.e. 150mm) may have their potential gross margin reduced by up to $100 per hectare per annum.

Conversely, applying the optimal amount for the higher capacity soils (50 to 60 kg N per crop) across the 90mm soil will only reduce its potential gross margin by $10 per hectare per annum.

Note that the $25 to $30 per ha cost of the extra fertiliser applied is not the same as the final reduction in business profit of applying the extra fertiliser. The reduction in business profit is the reduction in the total gross margin from 33kg N to 50kg N.

It can be seen that PAWC will have large economic effect even when the optimal fertiliser rate is applied to each PAWC. A 25% reduction in PAWC (150mm down to 120mm) leads to a 27% reduction in potential gross margin. A 40% reduction in PAWC (150mm down to 90mm) leads to a 65% fall in potential gross margin (i.e. comparing 150mm at 50 - 60kg N to 90mm at 33kg N).

What does it mean?

APSIM leaves out some factors that could reduce the size of potential fertiliser responses that can be gained at the paddock level. Even so, if a CQ farming paddock was 200ha in size, was low in available nitrates and had 30% of each of the above PAWC's, applying 30kg N/ha/crop across the paddock could cost the farm business something in the vicinity of $2,500 to $5,000 per annum for that one paddock compared to the strategy of fertilising each PAWC at its individual optimal rate.

On the other hand applying 60 kg N/ha/crop as a blanket rate across the paddock only reduces the economic optimum by about $300 per annum for the total paddock and significantly increases the overall profitability of the paddock when compared to applying a sub-optimal blanket rate suitable only for the 90mm PAWC portion of the paddock.

It appears uneconomic to invest in technology to apply optimal fertiliser rates to each soil PAWC as they occur across paddocks in CQ. The flatness of the response curve to applied fertiliser N and the variability of seasonal rainfall work strongly against getting a return to such an investment. Variations in soil PAWC that are more extensive could possibly be treated separately. These may be evident as variations between farms and/or farming districts.

PAWC is also an inherent soil characteristic that cannot be economically increased. At current costs and returns, lower PAWC soils will be become more risky and less economic to farm once cropping activities reduce their inherent soil fertility. It would appear that paddocks predominately made up of low PAWC soils will be less likely to be farmed in the future due to their low and highly variable returns.

8. *Modelling tactical N fertiliser application*

Why was the work done

A number of farm businesses within CQ now have the ability to apply all of the fertiliser N requirements for the following crop at the time of planting. This timely application of fertiliser significantly reduces the risk of the more traditional approach of applying fertiliser some weeks or months prior to planting.

Applying fertiliser N at planting may also allow the potential needs of the crop to be better judged, allowing the rate of fertiliser N applied to be varied to better match these expectations.

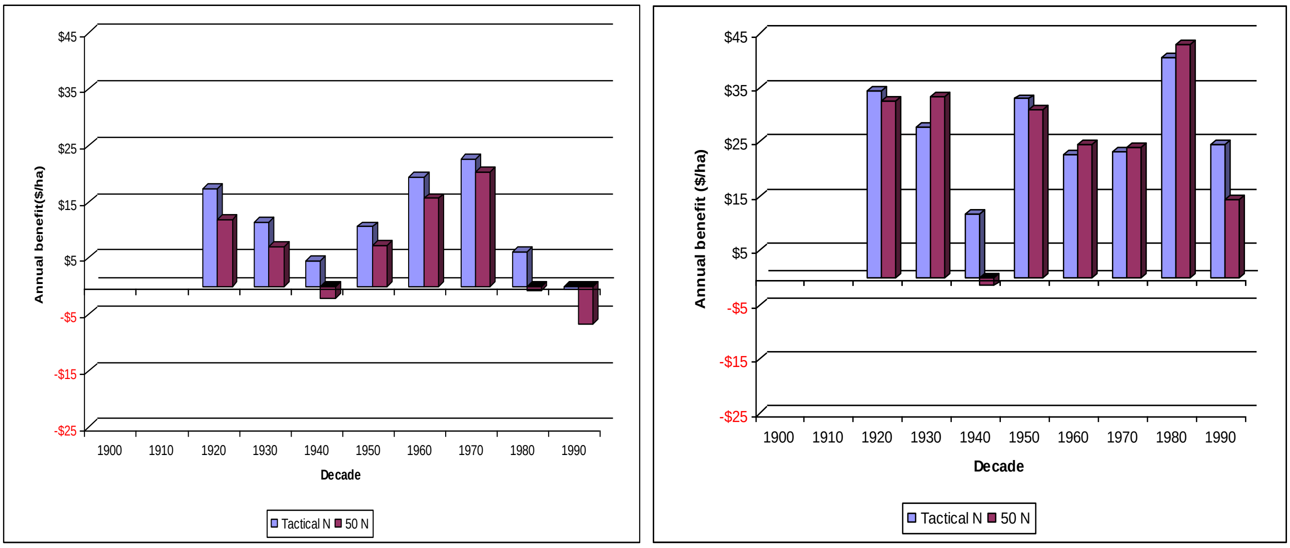
Research in Southern Queensland on wheat (Dalal et al 1997) has suggested that the optimal amount of nitrogen fertiliser to apply at planting can be found by measuring both soil water and soil nitrates prior to sowing. N fertiliser is added until a ratio of 1:1 of total soil NO_3 (kg/ha) and soil water (mm) is achieved.

How was the work done?

APSIM model runs were generated for a medium nitrate soil at Capella with an average PAWC to test whether it was better over time to apply fertiliser with a set amount applied to each crop at planting or to vary the fertiliser N applied according to the relationship of soil NO_3 and soil water.

What happened?

The average annual benefit of applying nitrogen fertiliser either tactically or in fixed amounts per crop to either monoculture sorghum or sorghum and wheat grown as opportunity crops was calculated (Figure 11). The climate data for eight separate decades is shown. For this example, the average tactical rate was slightly less than the fixed rate of 50kg N/crop but varied between zero and 160kg N/ha/annum for the opportunity cropping runs. The higher rate was achieved where two crops were grown in one year. Tactical amounts applied to sorghum varied between zero and 100kg N/ha/annum.



(a) (b)

Figure 11 Annual benefits per hectare of applying nitrogen fertiliser to (a) monoculture sorghum or (b) opportunity cropped wheat and sorghum at Capella on medium nitrogen, average PAWC soil.

What does it mean?

There is obviously an economic advantage in applying fertiliser N at planting when a good planting opportunity arises (and not before) but there does not appear to be much economic difference between applying fertiliser either tactically or in relatively fixed amounts at planting, even on a soil that has been farmed for some 35-40 years. Adopting a strategy of applying a widely varying rate of N fertiliser at sowing in response to antecedent soil water and N appears to have little advantage over a more average set rate.

It is important to spend time determining a suitable 'set' rate for the paddock in question. This could be done by fertilising strips within the paddock at a variety of repeated rates or by visiting similar paddocks that have a known cropping and fertiliser application history.

Investing funds to apply fertiliser at planting when a good planting opportunity is received can be justified however investing funds to fine tune the rate at which fertiliser is applied to individual crops may not be. An educated guess on the basis of experience and outlook is as good as any other currently available predictor.

9. Modelling the application of N fertiliser to wheat

Why was the work done

Wheat delivered to various grain depots around the Central Highlands has shown a general decline in grain protein over recent decades. At the same time, paddock trials have shown that applying sufficient fertiliser N to wheat to achieve consistent protein premium payments can be quite risky at current costs and returns even though soil tests indicate a nitrogen deficiency in cropping soils.

It is believed that the riskiness of applying fertiliser to wheat can be reduced if the amount applied is better targeted to meet the precise needs of the growing crop and applied at planting in a one pass operation.

To test this belief wheat growing was modelled under a number of soil, climate and fertiliser application scenarios. This was done to provide insight into the likelihood of these strategies reducing the riskiness and/or improving the return of applying N fertiliser to wheat crops on the Central Highlands.

How was the work done?

APSIM was configured so that wheat would only be planted at Capella in those years where at least 2/3 of the profile was wet (about 100mm stored water) and a planting rain of 25mm or more was received during a planting window that extended from early April to the middle of June. Applying extra fertiliser to wheat planted with lower stored water is unlikely to be economic given the poor start to the crop and its consequent low yield potential in most years.

APSIM was configured to apply fixed rates of 0, 50, and 100 kg N/ha/crop to wheat at planting over a number of thirty-year climate sequences. The soil modelled was considered to be a typical downs farming soil with a PAWC of 120mm. Fertiliser N was also applied tactically at planting by adding N fertiliser until a ratio of 1:1 of total soil NO_3 (kg/ha) and soil water (mm) was achieved.

Relationships between yield, in-crop rain, starting soil water and SOI phase at planting were calculated. Gross margin distributions were calculated for each fertiliser treatment.

What happened?

About 65% of years at Capella will produce the planting opportunity set for wheat in the model, if the paddock has been fallowed over the summer.

The correlation between in-crop rain and final yield under the planting conditions chosen was about 75%. This means that 75% of the variation in final yield could be attributed to the rain that fell after planting and before harvest.

Also, under the planting conditions chosen, the soil water at planting determined only about 8% of the final yield variation. In other words whether the profile is 2/3 full and receives a planting rain or 3/3 full and receives a planting rain does not matter much to the final yield of the wheat crop.

The correlation between the starting soil water and in-crop rain was about minus .05%. This means that having a reasonable amount of stored soil water and getting a reasonable planting rain did not give any indication whether the remainder of the wheat season was going to be good, bad or average.

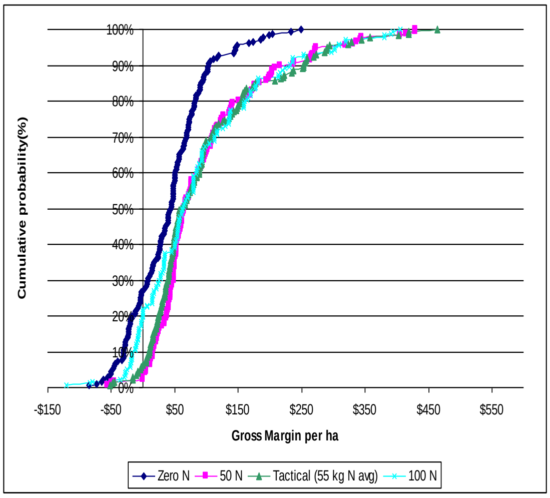
The phase of the SOI at planting had very little relationship with in-crop rain received or final yield. Most of the sowings were in the April-May period. The SOI phase system prior to this period does not have a strong signal (Rainman v3.2). Strongly significant effects are evident from the May-June SOI phase. The other tempering effect was the configuration that allowed sowing with soil 2/3 full or more. This would temper the effect of in-crop rain to some extent but a lesser extent than soils of very high water-holding capacity.

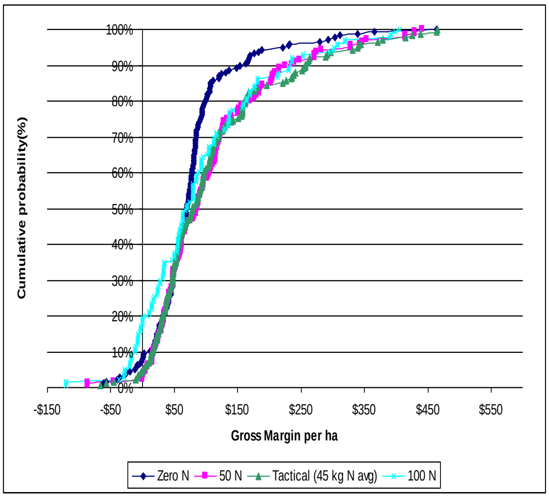
What does it mean?

Figure 12 (a) shows the results over time of applying fertiliser at planting to wheat grown on a low nitrate soil. It can be seen that **if a reasonable wheat planting opportunity is received** for an older soil that has been farmed for a large number of years (say 40 - 50 years) then applying fertiliser at planting will provide an economic return in most years.

Unfortunately, growing wheat on these old soils at current prices and protein premiums will produce a gross margin of less than $150 per ha in about 80% of years.

Figure 12(b) shows the results of applying fertiliser at planting to wheat grown on a medium nitrate soil. If a reasonable wheat planting opportunity is received and the soil has been farmed for about 30 to 40 years, applying N fertiliser at an optimal rate at planting will still only show an economic return at current costs and returns in about 40% of years when compared to not applying N fertiliser. Applying fertiliser above the optimal rate at planting to achieve consistently high protein wheat increases riskiness and reduces returns when compared to a more optimal rate of N application.





(a) (b)

Figure 12 Gross margin distributions for monoculture wheat grown on (a) low nitrate, medium PAWC soil and (b) an average nitrate, medium PAWC soil at Capella.

The risk of growing wheat on low nitrate soils on the Central Highlands can be reduced if fertiliser is applied at planting and not before. Even so wheat remains a fairly risky crop with relatively low profitability on the older cultivation soils - even if a good planting opportunity is received and fertiliser is applied optimally.

The riskiness of returns is **unlikely** to be reduced by varying the rate of fertiliser applied to wheat crops at planting on the Central Highlands in response to either starting soil water, SOI phase or starting soil nitrate on soils that have been farmed for some time. None of these factors are good predictors of the final yield of the wheat crop grown under the planting conditions modelled for this exercise.

10. Modelling short term ley farming systems that are grazed

Why was the work done

Farming system managers are faced with a number of choices in relation to the decline in soil nitrates that occurs under continuous farming systems in Central Queensland.

As farming activities continue and soil nitrates decline, the farm manager has a number of options. For example, they could:

- apply fertiliser (in increasing amounts) and continue farming,
- cease farming and return the paddock to a grass based pasture, or
- implement a short term ley farming system where much of the soil nitrate needs of cereal crops are supplied by a short term ley legume. Short term in this case means that the ley is maintained for one or two seasons but rarely two years. In all cases the farm manager intends to graze the ley legume.

How was the work done?

A gross margin analysis of the range of outcomes for each system has been completed for three separate soil plant available water capacities (PAWC's). These gross margins have been adjusted for livestock capital where necessary. This approach does not fully represent the choice faced on each individual property but should give a general insight into the nature of the choice.

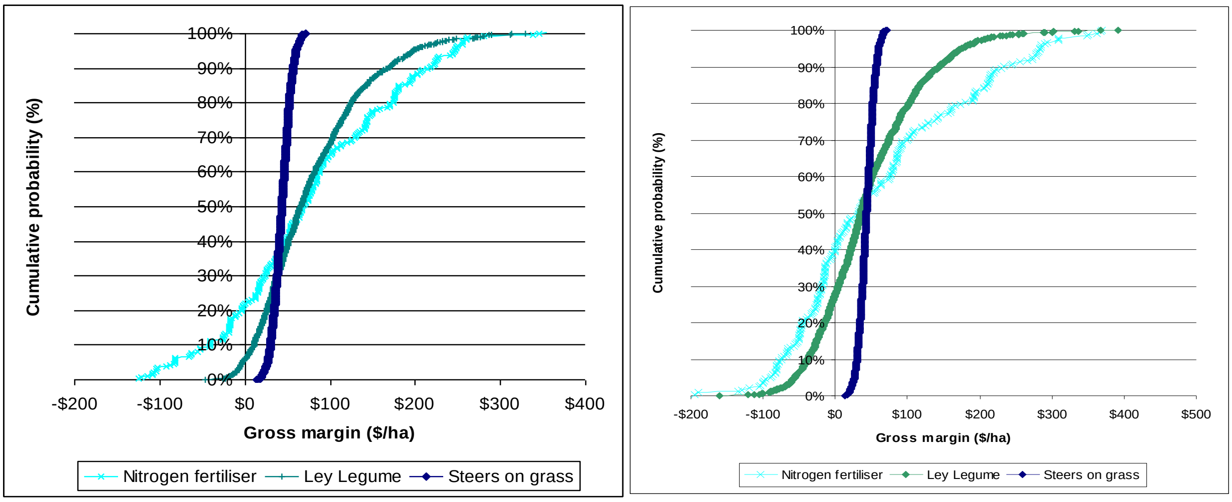
All soil's in the analysis had been farmed for some time and have very low available soil nitrates. They need fertiliser inputs to successfully grow cereal crops. One paddock was modelled as having a PAWC considered to be low (100mm), another was average (120mm) and the last was high (150mm).

What happened?

Figure 13(a) shows for a low nitrogen, **medium PAWC** soil that nitrogen fertiliser applied to a continuous cereal farming system will produce a higher gross margin than a straight grazing enterprise in about 60% of years.

Continuous cultivation with fertiliser will produce a negative gross margin in about 20% of years whereas grazing enterprises are unlikely to ever show a negative gross margin at the paddock level.

Short-term ley farming systems on this soil do not show the same level of negative gross margins as continuous farming systems. They also do not have the same “upside” as the continuous farming systems.



(a) (b)

Figure 13 Potential gross margins for alternate farming systems on (a) medium PAWC low nitrogen soil at Capella and (b) low PAWC, low nitrogen soil at Capella

Figure 13 (b) shows for a low nitrogen, **low PAWC** soil that nitrogen fertiliser applied to a continuous cereal farming system will produce a higher gross margin than a straight grazing enterprise in only about 45% of years. This together with a negative gross margin in about 40% of years will encourage few system managers to continue farming such a paddock.

Ley farming systems on this soil do not show the same level of negative gross margins as continuous farming systems. They also do not have the same “upside” as the continuous farming systems. In 40% of years they will produce a higher gross margin than a straight grazing enterprise.

Grazing enterprises are likely to be chosen by some managers as a low risk option on **low PAWC** soils.

Figure 14 shows for a low nitrogen, **high PAWC** soil that nitrogen fertiliser applied to a continuous cereal farming system will produce a higher gross margin than a straight grazing enterprise in about 85% of years and a negative gross margin in about 12% of years.

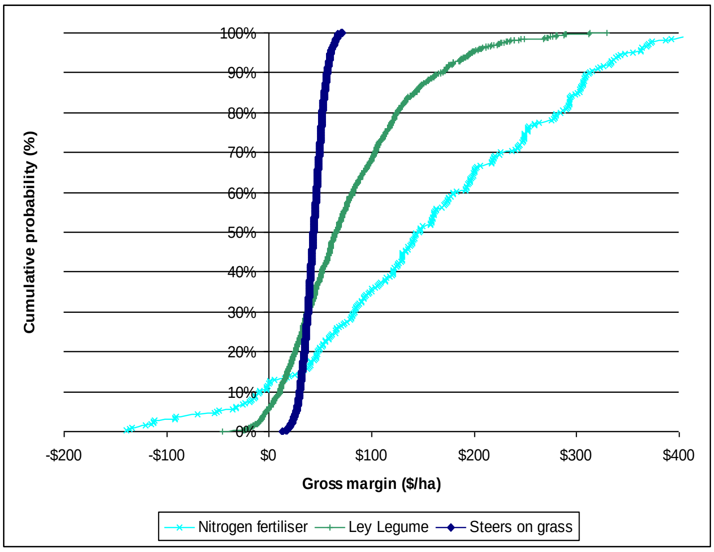


Figure 14 Potential gross margins for alternate farming systems on a high PAWC, low nitrogen soil at Capella

A short-term ley farming system will be less profitable than a fertilised continuous farming system in about 85% of years and is unlikely to be pursued on this **high PAWC** soil even though soil nitrates are very low.

Most farm managers would be expected to apply fertiliser to a zero till farming system on such soils even though it is slightly more risky that less intensive systems.

What does it mean?

Soil PAWC will have a large effect on the type of strategy followed to counteract the soil nitrate decline problem.

Paddocks with a low or very variable PAWC are more likely to be sown to pasture or some form of ley legume once available soil N is largely exhausted.

Paddocks with a medium to high PAWC will be more likely to be cultivated and fertilised to grow grain crops. The attitude of the individual manager to the perceived riskiness of each farming system and the overall mix of enterprises on the farm will also affect the choice.

11. Modelling the response to N fertiliser

Why was the work done

Applying nitrogen fertiliser is in many ways similar to other short-term investments. Most investments require an amount of money to be spent in one period of time with the hope that it will be returned (plus interest) in another. The rate of return and the variability of the returns gained can also be a measure of the riskiness of the investment.

To discover more about nitrogen fertiliser as an investment, the individual returns to expenditure on nitrogen fertiliser at the "Moonggoo" CQSFSP trial site were calculated for each crop and treatment since the beginning of the trial. These were then compared to returns calculated from output of the APSIM model to see if a pattern could be established between returns in the real and modelled worlds.

How was the work done?

Individual gross margins were calculated for each crop grown at "Moonggoo" over the past four and a half years.

The return to fertiliser was then calculated as the difference between the zero N gross margins and the applied N gross margins of the same treatment. These returns were converted to percentage returns by investment analysis techniques.

In addition to the calculation of actual returns based on paddock scale trial results, returns were also modelled using APSIM.

To do this APSIM was configured to grow crops of wheat and sorghum on an opportunity cropping basis at Capella on a soil similar to the majority of the soil found in the trial paddocks at "Moonggoo". The outputs of the biological model were then applied to a representative whole farm model that calculated the annual return on investment for each fertiliser treatment modelled. The model was run for eight overlapping thirty-year sequences to capture the climatic variability over the past 100 years at Capella.

Nitrogen fertiliser was applied at a fixed rate of 0, 50 or 100 kg N/ha/crop in the modelling exercise. Fertiliser N was also applied tactically at planting by adding N fertiliser until a ratio of 1:1 of total soil NO_3 (kg/ha) and soil water (mm) was achieved.

What happened?

Fertiliser N has been applied to the actual trial crops grown at "Moonggoo" on the basis of either a budgeted amount that has ranged between 30 to 40 kg N/ha/crop or a fixed amount of 60 kg N/ha/crop. The rate of return on capital was calculated for each fertiliser treatment.

Figure 15 shows the distribution of returns earned by each crop grown with these fertiliser treatments.

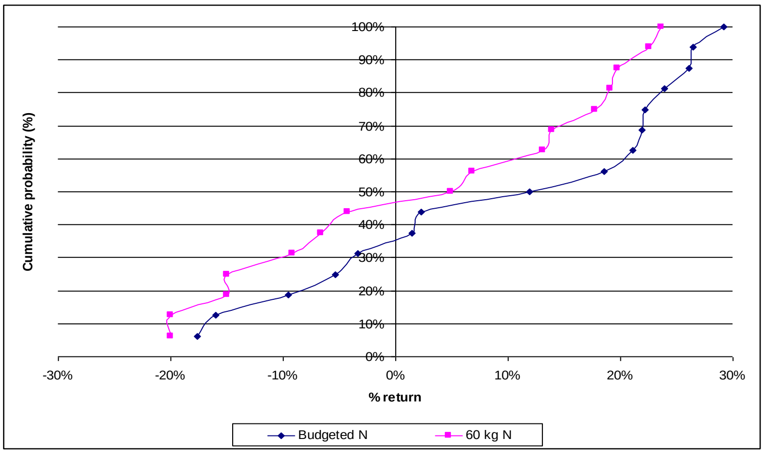


Figure 15 Distribution of returns to N fertiliser applied at "Moonggoo" CQSFSP trial site.

It can be seen that the returns to applied fertiliser over the past 4½ years have ranged between -20% and + 30%. The application of fertiliser under trial conditions at "Moonggoo" produced quite variable results over time. As the trial was completed at the paddock scale with normal farm machinery and timeliness, these returns are probably representative of the actual results achievable by other farm businesses.

The graph indicates also that funds invested at the budgeted rate will always outperform funds invested at the 60kg N/ha fertiliser rate.

Funds invested in either rate of fertiliser application also lost money in 40% to 50% of years.

Figure 16 shows the distribution of farm returns on an annual basis for the fertiliser treatments applied in the APSIM model.

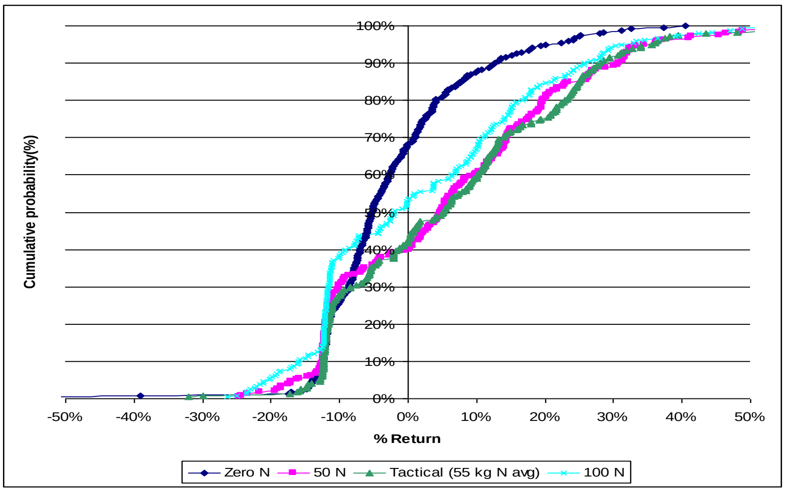


Figure 16 Cumulative distributions for the annual return on investment for a representative specialist farm business at Capella. Faming system modelled was opportunity cropping on an average PAWC, low nitrate soil.

What does it mean?

The range of return on assets for the modelled farm business appears very similar to the range of returns for the paddock results. This is plausible as both sets of results are driven by the underlying investment response to applied nitrogen fertiliser.

The APSIM output suggests that applying fertiliser at a fixed rate of about 50 to 55 kg N/ha/crop at Capella on downs soils that have been farmed for 40 - 50 years will provide a farm business that outperforms both unfertilised and more highly fertilised farm businesses. The actual trial results suggest that 30 to 40 kg N/ha/crop would probably be more efficient.

If we could match the even plant population, crop emergence and weed free status of crops grown in APSIM, then it is possible that higher rates of fertiliser may show better rates of return in the paddock. Until that time, the optimum investment appears to be the budgeted rate currently applied at "Moonggoo".

As the overall returns of specialist cropping properties at Capella are driven by a very variable climate, the percentage of years in which an operating loss will be suffered will be quite high. Even though applying fertiliser at the optimal rate will improve business performance, the underlying business still has to be financially well managed and resilient to the severe shocks that can be delivered by the variable climate.

12. Modelling the riskiness of alternate ley and legume farming systems

Why was the work done

A number of options are available to farm managers who wish to cease farming a particular paddock in Central Queensland. This can occur when a soil is depleted in fertility such that it no longer supports profitable dryland cropping without fertiliser.

One option is to return cultivation land to a grass pasture. This is seen as a low cost but low return option. The option of planting the land to butterfly pea is more costly but has a higher potential output even though the pasture may only be grazed for a portion of each year. Another option for a long-term pasture exists in the form of leucaena in Central Queensland, which can be highly suited to planting into ex-cultivation country. All of the above options will improve soil fertility, although at different rates.

These options are normally compared on the basis of establishment costs and then on the basis of expected output. They can also be compared on the range of possible outcomes or riskiness of each option.

As both leucaena and butterfly pea have little information available about the range of outcomes possible for their pastures, a modelling exercise was completed to delve into the relative riskiness of each pasture.

How was the work done?

A ten-year investment model based on the purchase and development of a 200 ha paddock to either grass; butterfly pea or leucaena was constructed. Because differing amounts of capital were invested at different times in each scenario, cash flows were calculated after the effect of tax was allowed for.

Each investment scenario was further modelled in @Risk to investigate the variability of outcomes for each investment scenario.

What happened?

Figure 17 indicates the expected cash flows for each development option. The cost of land purchase at the beginning of the investment and its subsequent sale at the end of the investment has not been included as it would be the same for each.

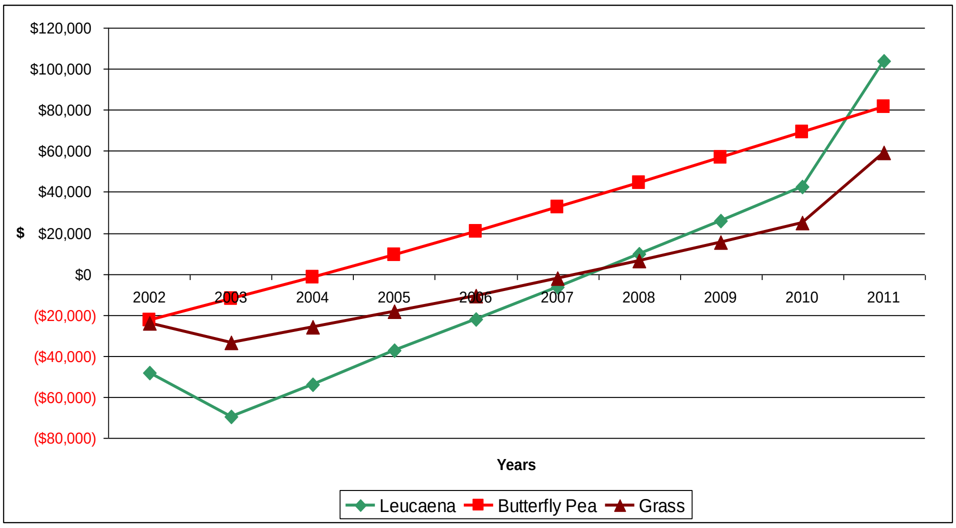


Figure 17 Expected cash flows over a ten-year investment period for developing a 200ha cultivation paddock to grass, butterfly pea or leucaena.

The cash flow for the grass and leucaena options dip in the second year and kick in the final year mostly due to the lag effect on income of purchasing livestock in one year and then selling them in another. The butterfly pea pasture would normally buy and sell steers for grazing within the one year, thereby not showing the same cash flow effect.

Our expectation is that a butterfly pea pasture will provide much quicker cash incomes after establishment due to its ability to produce in the same season that it is planted. This allows the butterfly pea cash flow to stay well ahead of both the leucaena and grass options for the first nine years of the investment.

Each option could have a range of outcomes above or below the expected cash flow line due to variation in such things as the purchase and sale price of steers, the weight gain during grazing, the number of days grazing achieved and the number of steers purchased.

The investment could encounter a run of poor results due to lack of rain, poor livestock purchasing decisions or a pasture development that performs below expectations.

Figure 18 shows the range of outcomes for developing the grass pasture when all of the variables that can affect the cash flow are applied to the cash flow budget and recalculated a large number of times.

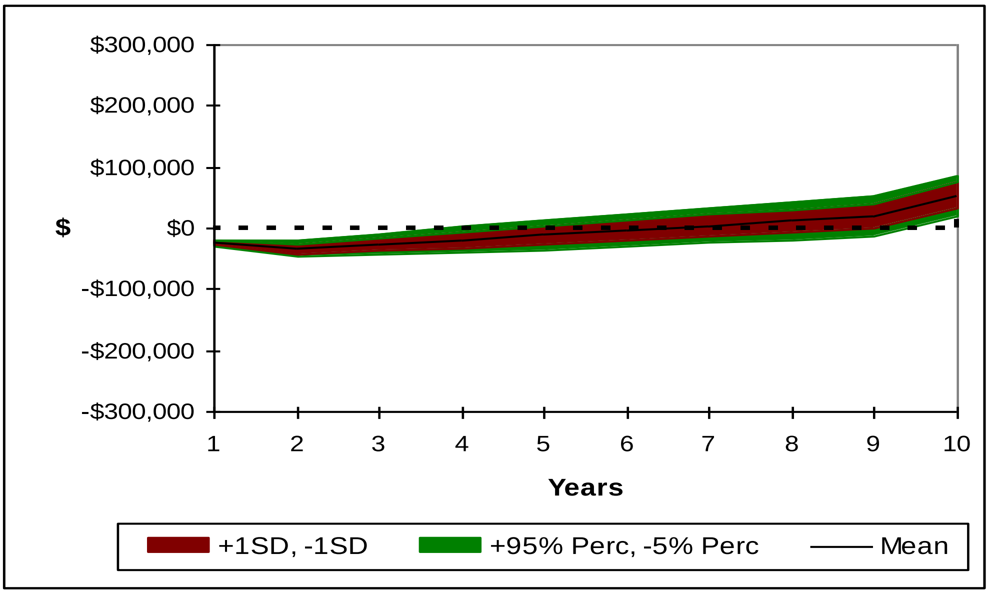


Figure 18 Range of possible cash flow outcomes for developing a 200 ha ex-cultivation paddock to grass pasture in Central Queensland.

The low stocking rates, low outputs and longer periods of grazing of a grass pasture limit the range of outcomes. This reduces the riskiness of the development but also limits its ability to generate better returns.

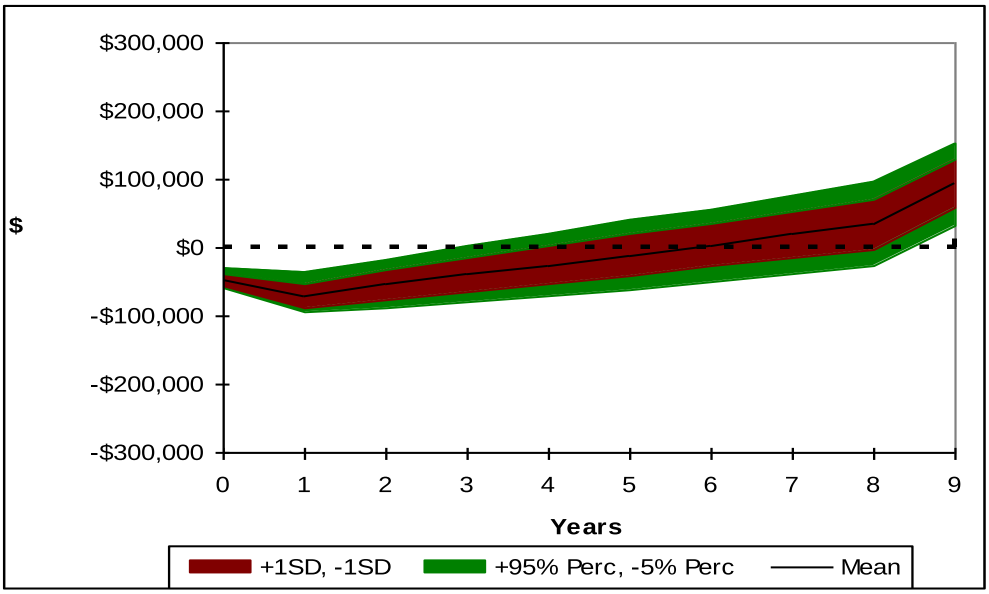


Figure 19 Range of possible cash flow outcomes for developing a 200 ha ex-cultivation paddock to leucaena in Central Queensland

Figure 19 indicates that an investment in leucaena will require additional cash reserves compared with the grass development, will take about the same time to break even under a worst case scenario but should finish up with a considerably better return at the end of the ten years.

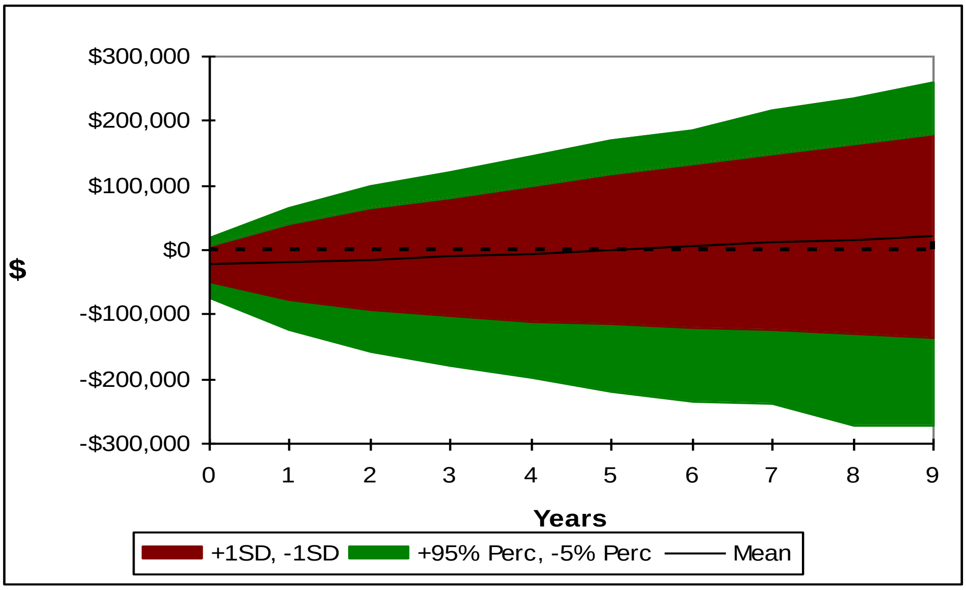


Figure 20 Range of possible cash flow outcomes for developing a 200 ha ex-cultivation paddock to butterfly pea in Central Queensland

The range of outcomes for the butterfly pea investment (Figure 20) is substantially greater than that for either a grass pasture or a leucaena development. It could outperform the other options under favourable conditions. It has an equal chance of producing substantial losses if things did not go as planned.

The greater range of outcomes that can arise from investing in butterfly pea pastures when compared to the most likely alternatives seems to depend upon a few key factors.

Firstly, butterfly pea pastures are normally grazed for short periods at high stocking rates and then allowed to recover. This quite often means that large amounts of livestock capital have to be accessed for short periods of time. For example, to stock the leucaena pasture established in the example could cost about $50,000 each year at current values. This could increase to $300,000 to stock the same area planted to butterfly pea because of the higher stocking rate and shorter grazing period, even though the same class of cattle are used to stock the pasture.

Secondly, even though the larger mobs of cattle required to graze butterfly pea pastures effectively are owned for much shorter periods of time than those grazing either grass pastures or leucaena pastures, there is still a considerable risk of the cattle market moving during the period of ownership. In the analysis it was stipulated that the cattle would be bought and sold on the same market 75% of the time with a butterfly pea development. Grass and leucaena developments did not have this stipulation.

The 25% of times that the market went either up or down against the purchase price during the period of grazing accounted for nearly all of the variation generated by the investment in butterfly pea. The much larger numbers of cattle involved in the butterfly pea development tended to multiply losses or gains made on the sale of livestock compared to the options that invested in lower stock numbers per annum or had better liveweight gains per head.

What does it mean?

A number of sources of risk can make the outcome of any farm investment uncertain.

In this example the accepted grazing strategy for butterfly pea significantly increases its riskiness as an investment when compared to alternate ley pastures in Central Queensland.

This increase in risk is mostly due to the price risk associated with the short term grazing of productive pastures by sale cattle.

While only small areas of any property are planted to butterfly pea pasture, the price risk associated with its grazing should not be an insurmountable problem. Larger areas that are grazed as recommended could increase the overall riskiness of the farm business.

13. Modelling the effect of soil nitrate run down under zero till farming systems

Why was the work done

Soil nitrate is an important indicator of the fertility of cropping soils in Central Queensland. As crops continue to be grown, the level of available soil nitrate declines. If the decline continues, most cereal crops will eventually require the addition of nitrogen fertiliser to provide a satisfactory crop yield.

There are currently no clear rules as to when nitrogen fertiliser will be required and in what amounts for Central Queensland cereal farming systems. As paddock results for fertiliser trials are notoriously variable, it was considered that crop modelling using APSIM might be able to throw some light on the topic.

How was the work done?

APSIM was configured to grow cereal crops over thirty year climate sequences at Capella. The soil was characterised as a 120mm PAWC soil that had been farmed for about 30-35 years.

Therefore the soil was thirty years old and about to be modelled for another thirty years of cropping. Fertiliser was either applied at a tactical rate or not applied to crops grown under any of the farming systems modelled. Soil nitrate, grain yield and grain protein information was collected for each crop grown in each climate sequence.

What happened?

Cash flow outcomes for example farm businesses have been modelled using APSIM integrated into a whole farm modelling process (Figure 21). This analysis applied fertiliser at tactical rates to monoculture sorghum and opportunity cropping wheat and sorghum on an average PAWC, medium nitrogen soil at Capella, commencing in 1970.

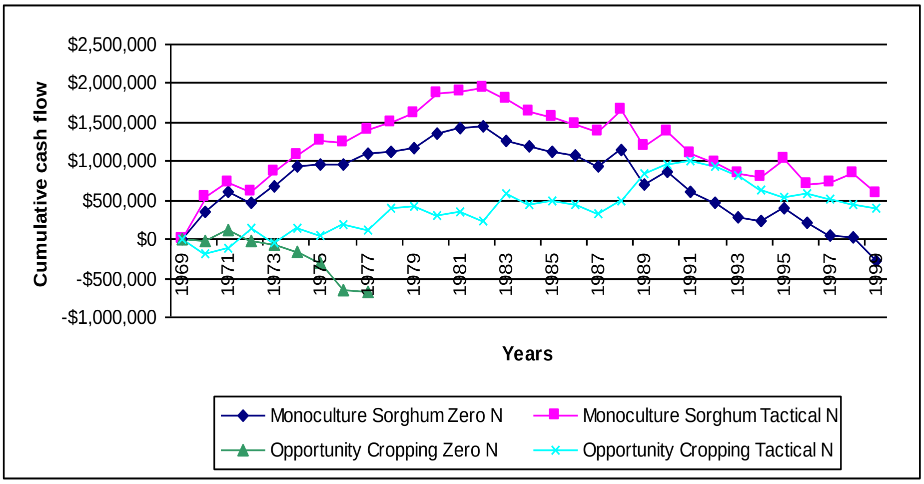


Figure 21 Modelled cumulative cash flow for monoculture sorghum and opportunity cropping of sorghum and wheat grown on an average PAWC, medium nitrogen soil at Capella with two rates of fertiliser use.

Farmers who applied an optimal fertiliser strategy were eventually more profitable than their low input neighbours. It is very noticeable that the planting of winter crops within the opportunity cropping system during decades that had very summer dominant rainfall patterns (the early 1970's) seriously diminished the profitability of opportunity cropping compared to monoculture sorghum. Concentrating on monoculture sorghum during decades that received more winter dominant falls seriously diminished the profitability of monoculture sorghum farming with or without fertiliser compared to opportunity cropping (the late 1980's).

Figure 22 shows the individual gross margins achieved between 1970 and 1999 for monoculture sorghum grown at Capella with and without fertiliser. These gross margins were combined to form the cash flow shown in figure 21. Fertiliser was applied at a tactical rate that averaged 32 kg N/ha.

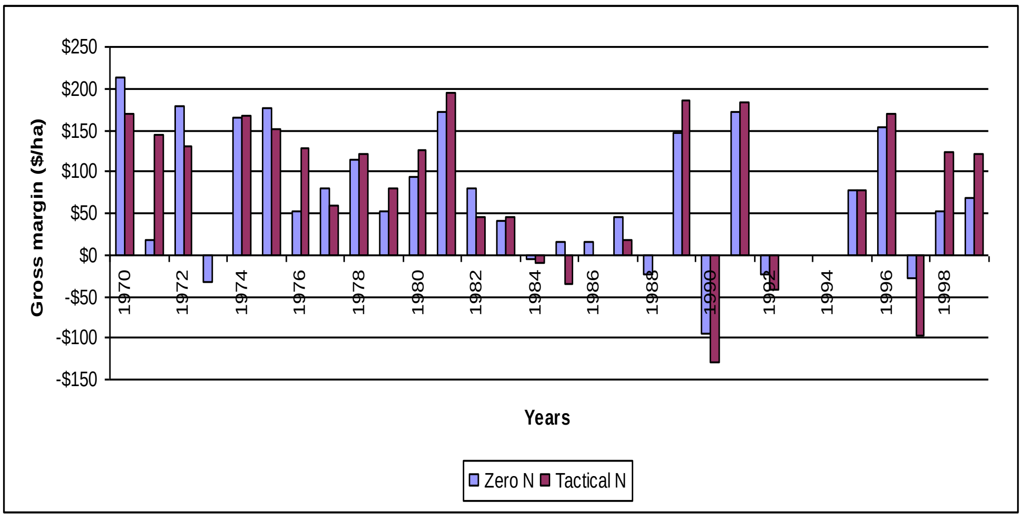


Figure 22 Modelled gross margins for monoculture sorghum on medium nitrogen, average PAWC soil at Capella – 1970 -1999

Perusal of the individual gross margins reveals that the tactical application of nitrogen fertiliser to monoculture sorghum only gave significant benefit on about six occasions over the thirty-year period.

It also contributed to increased losses on three occasions.

Perusal of Figure 23 reinforces the investment benefits of applying nitrogen fertiliser under opportunity cropping.

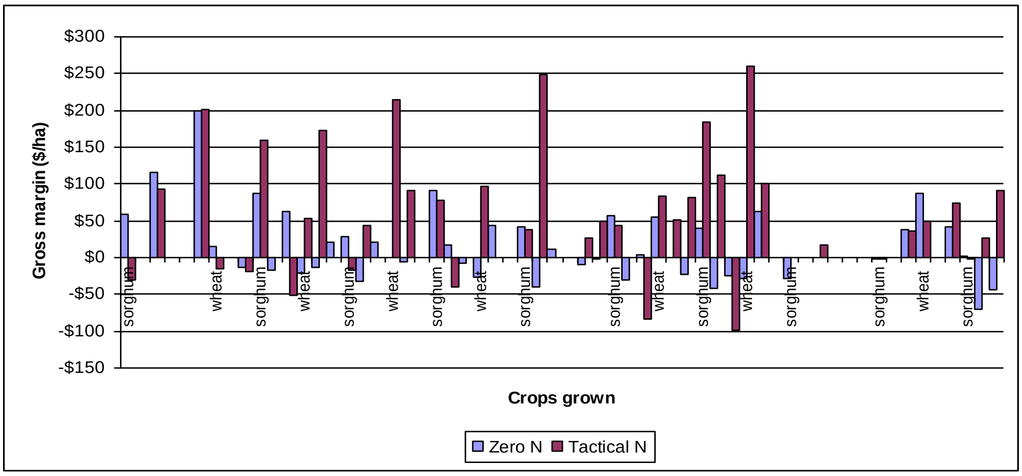


Figure 23 Modelled gross margins for opportunity cropping on medium nitrogen, average PAWC soil at Capella – 1970 -1999

It should also be noted that there are now six occasions over the 30-year investment period where losses are increased through the application of nitrogen fertiliser. Significant benefits would be noticed on about twelve occasions over this period.

What does it mean?

The modelling sequences gave no clear guidance as to when to begin applying nitrogen fertiliser to monoculture sorghum farming systems. On many occasions, following the "best management" rules for fertiliser application currently available will lead to significant expenditures on fertiliser that are not recouped.

The increased cropping frequency arising from the opportunity cropping of summer and winter cereals requires that fertiliser be added in significant amounts on anything other than highly fertile soils. In some parts of Central Queensland, opportunity cropping of cereal crops using increased inputs may not increase long-term farm profitability and could increase business risk due to summer dominant rainfall patterns.

14. Modelling the returns to extra capital invested in zero till precision planting equipment

Why was the work done

Relatively few Central Queensland farmers currently own and use precision planters suitable for use under low tillage or zero till farming systems. Many are considering the purchase of an additional planter or improving the capability of their existing planter in an attempt to gain some of the perceived benefits of low tillage farming systems.

The cost of adding to or improving the planting capacity of any property needs to be weighed against the expected benefits if a reasoned decision is to be made.

How was the work done?

Figure 24 shows the yield and crop results of modelling opportunity cropping wheat and sorghum at Capella for the ten seasons between 1990 and 1999.

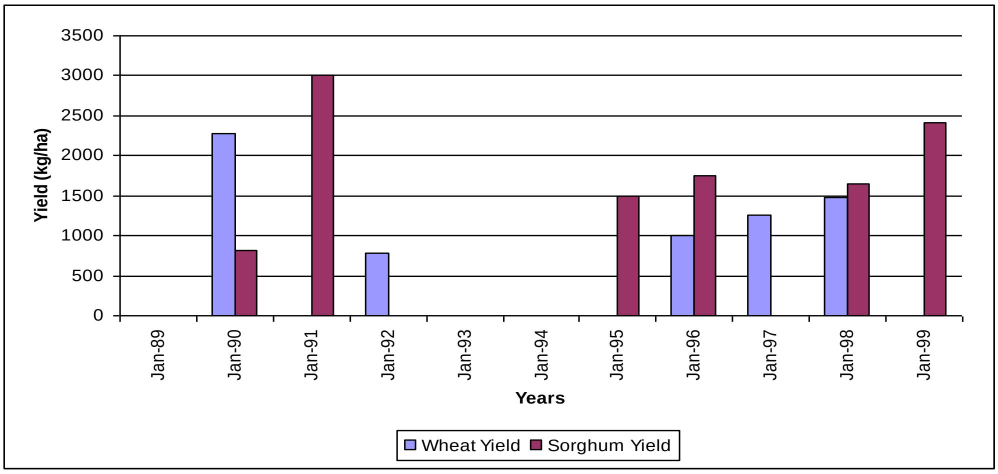


Figure 24 Yields for opportunity-cropped wheat and sorghum at Capella 1990 – 1999 as modelled by APSIM for average nitrogen, average PAWC soil. Nitrogen fertiliser applied at a tactical rate.

The question to be answered is “if you purchased precision planting technology in 1990, what yield benefits need to accrue to each sorghum crop grown before the planter expenditure is a profitable investment”.

Note that we expect that there will be no change in timeliness caused by the investment in extra precision. We also do not expect the performance of the wheat crops to be affected by the expenditure on planting precision.

What happened?

Table 2 Approximate annual rate of return after tax for capital expenditure on precision planting technology purchased in 1990 and used until 1999

		Average area planted per crop of sorghum		
Capital invested	Yield advantage gained through the investment	500 ha	1000 ha	2000 ha
$20,000	5%	14%	28%	56%
	10%	32%	57%	118%
$50,000	5%	-.1%	8%	21%
	10%	9%	22%	44%
$100,000	5%	-9.5%	-1%	8%
	10%	-0.72%	8%	22%

If access to precision planter technology cost about $20,000 then the investment would be profitable if at least 500 ha of sorghum were grown each time sorghum was planted and a 5% yield increase was achieved on average over the ten year investment period.

If the technology cost $50,000, then expected yield increases of at least 10% or expected average areas to be planted to sorghum of no less than 1000 ha would be necessary to entice the investment.

If the technology cost $100,000 to access, then a yield advantage of at least 10% would have to be achieved and more than 2000 ha would have to be planted when sorghum was grown during the ten-year investment period.

What does it mean?

Firstly, for the investment in precision planting technology to be made, the investment not only has to be profitable but it also has to be more profitable than the next best use of the funds. It can be seen that a considerable area of crop needing precision planting technology would have to be grown on a regular basis before adequate returns were made on the funds invested.

Secondly, cash flow and other financial considerations will also have a big impact on the decision to invest in precision planting technology for zero till conditions. While the investment may be profitable, the farm business must also have the capacity to either service the debt repayments as they fall due or provide the cash for the investment.

15. Modelling financial aspects of tactical N fertiliser application at Capella

Why was the work done

CQSFSP paddock trials undertaken on "Moonggoo" at Capella indicate a variable but profitable response to nitrogen fertiliser applied over the past 4½ years on reasonable quality downs farming soils that have been farmed for 30 - 40 years. The most profitable rate has been the "budgeted" rate that tries to estimate crop needs on the basis of soil water, soil nitrate and crop prospects at planting and then vary the amount applied accordingly.

Even so some local farmers with similar soils and farming conditions are reluctant to apply nitrogen fertiliser to their cereal cropping operations.

The financial and risk aspects of nitrogen fertiliser application on the Central Highlands need to be investigated to see if these factors may be holding back the greater adoption of fertiliser nitrogen.

How was the work done?

A modelling exercise using a representative specialist cropping business of the Capella district was completed to further consider the effect of these issues. The business was modelled to either grow sorghum alone or sorghum and wheat as opportunity crops.

To estimate the fertiliser needs of the business, fertiliser N was applied tactically at planting by adding N fertiliser until a ratio of 1:1 of total soil NO3 (kg/ha) and soil water (mm) was achieved. The rate of nitrogen applied per annum was calculated and graphed.

What happened?

Figure 25 shows the variability in the annual amounts of fertiliser applied tactically by APSIM to monoculture sorghum and opportunity cropping farming systems at Capella. The years modelled were 1970 to 1999.

Farm managers on such a property who chose to apply tactical rates of fertiliser to opportunity cropping farming systems would be faced with fertiliser bills in excess of $80,000 on nine planting occasions.

Over the thirty-year investment period, the farm manager would have to commit cash resources in excess of $2,200,000 to nitrogen fertiliser.

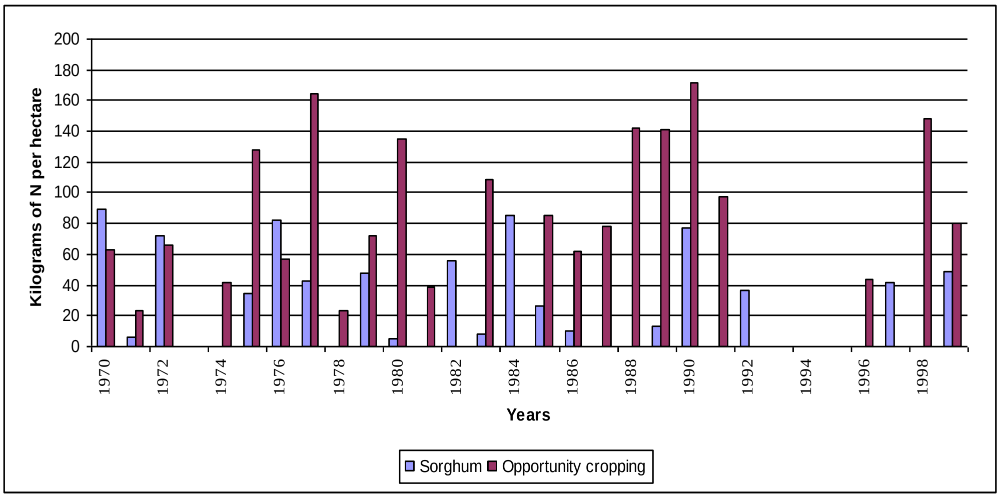


Figure 25 Kilograms of nitrogen applied per annum under monoculture sorghum and opportunity cropping at Capella on medium nitrogen, average PAWC soil. Nitrogen fertiliser applied tactically.

Perusal of the gross margin response to the fertiliser applied (data not shown) reveals that the tactical applications of fertiliser only occasionally corresponded with the years where a high return to fertiliser was gained.

What does it mean?

Having to find substantial cash sums to cover nitrogen fertiliser application at the recommended rate to be applied with the tactical N approach will severely test even the best managed specialist farming businesses in Central Queensland. This together with the knowledge that applied fertiliser will not always show a noticeable response will make it seem like a very risky business indeed.

There is also a considerable cash flow impediment to the purchase of nitrogen fertiliser in that it will obviously be seen as an *extra* cost.

The financial and risk perspective will have a considerable impact on the decision to purchase nitrogen fertiliser. This is even though it can be shown to be profitable to fertilise dryland farming systems in Central Queensland once soil nitrates become low.

16. Modelling mineralisation and denitrification of soil nitrogen in CQ farming systems

Why was the work done

A number of CQ farm managers have commented that while they felt wheat needed nitrogen fertiliser to perform at its best in some paddocks, they were very unlikely to fertilise sorghum growing in the same paddock. The reason for this difference was given partly as the desire to maintain a high grain protein in wheat and partly that fertilising sorghum probably would not improve its performance.

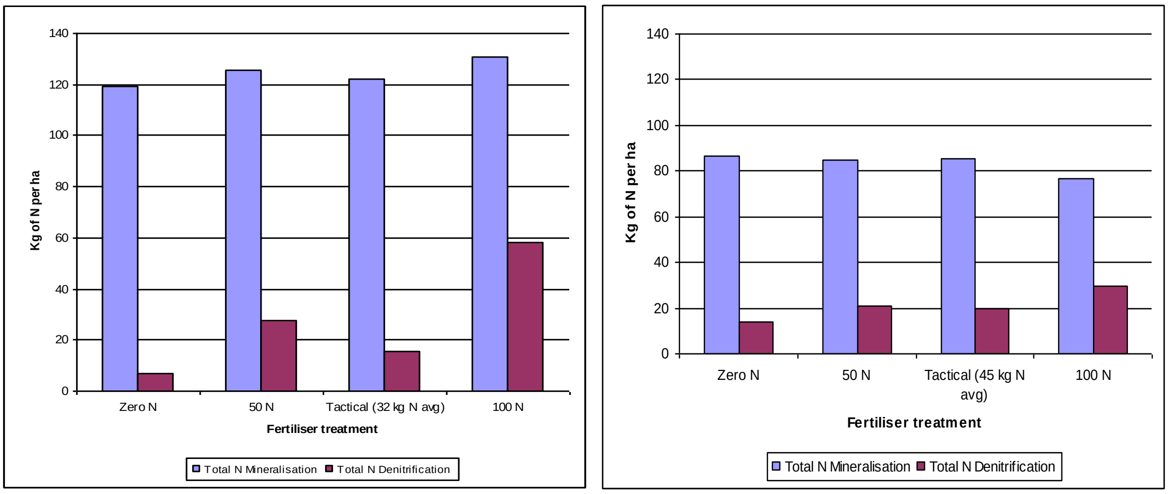
This difference in the apparent needs for nitrogen by two cereal crops in the same paddock seemed to be slightly inconsistent and some modelling runs using APSIM were constructed to see if any differences over time could be identified.

How was the work done?

APSIM has the ability to model the level of mineralisation and denitrification occurring under different farming systems. This capability of the program was used to gather information about the level of mineralisation and denitrification occurring under a monoculture wheat and monoculture sorghum farming system at Capella.

What happened?

The modelled results for mineralisation and denitrification of soil nitrogen under the two systems also show interesting differences. (Figure 26)



(a) (b)

Figure 26 Predicted average annual mineralisation and denitrification under (a) monoculture sorghum and (b) monoculture wheat on an average PAWC, medium nitrogen soil at Capella as modelled by APSIM

APSIM predicts that annual average mineralisation will be about 30% less in total over any thirty year period under monoculture wheat compared to that under monoculture sorghum. Additionally, denitrification is expected to be less under sorghum when optimal fertiliser strategies are used.

The figures suggest that the more likely occurrence of wetting and drying cycles under sorghum grown during our summer dominant rainfall periods would tend to increase mineralisation of soil nitrogen compared to the expected mineralisation under the monoculture wheat system. (J. Doughton personal communication)

What does it mean?

The increased rate of mineralisation predicted by the model under monoculture sorghum compared to monoculture wheat (Figure 26 (a)) confirms industry experience that there is little economic response to fertiliser nitrogen applied to monoculture sorghum crops grown on soils that have a high mineralisation capacity and/or a reasonable level of soil nitrates available.

Sorghum is actively growing when most of the nitrogen mineralisation is likely to occur under Central Queensland conditions and therefore more likely than wheat to efficiently use that source of nitrogen.

Wheat may also be planted into much cooler soil conditions after mineralisation and subsequent denitrification has possibly occurred over the previous summer, thereby reducing the supply of nitrogen available from the soil.

For these reasons wheat may need nitrogen fertiliser to have the same relative yield potential as sorghum and maintain a reasonable level of grain protein. Sorghum grown in the same paddock at a different time of the year may not need nitrogen fertiliser to perform at a satisfactory level.

17. Calculating the cost of butterfly pea seed production

Why was the work done

A number of Central Queensland producers have decided to hold back a paddock of butterfly pea from grazing so that they could then harvest their own seed. This seed is normally to be used to plant further areas of pastures on their own property.

A number of different costs are incurred in this exercise, some of which are not readily apparent when the initial decision is made to set the paddock aside.

To help with this decision, a cost of production exercise has been completed for butterfly pea seed in the hope that the choice between commercially available seed and home produced seed may become clearer. These costs do not relate to the commercial production of butterfly pea seed for sale.

How was the work done?

The costs of producing butterfly pea seed were compiled. Some are direct cash costs associated with seed production and some are costs associated with the value of the grazing foregone. All costs are based on industry experience or estimates.

The costs were compiled under three scenarios. The first was where a below average grazing opportunity was foregone, the second was where an average grazing opportunity was foregone and the final scenario was where an above average grazing opportunity was foregone.

What happened?

Butterfly Pea Seed Costs

	Grazing Opportunity		
	Below average	Average	Above average
	$/ha	$/ha	$/ha
Value of grazing foregone	$150	$250	$350
Desiccation costs	$18	$22	$26
Harvest costs	$50	$55	$60

On farm aeration and cleaning cost	$15.00	per ton
Seed grading cost	$125.00	per ton
Seed bagging cost	$1.50	per bag
	40	bags per ton
Freight to seed cleaning firm	$15	per ton
Freight from seed cleaning firm	$10	per ton
Seed grade out	10%	of harvested yield

Cost per kg for Cleaned, Graded and Bagged Butterfly Pea Seed

Paddock Yield (kg/ha)	Seed Cost in $/kg		
	Below average	Average	Above average
50	$5.04	$7.44	$9.84
100	$2.64	$3.84	$5.04
200	$1.45	$2.04	$2.64
300	$1.05	$1.45	$1.85
400	$0.85	$1.15	$1.45
500	$0.73	$0.97	$1.21
600	$0.65	$0.85	$1.05
700	$0.59	$0.76	$0.93
800	$0.55	$0.70	$0.85
900	$0.51	$0.65	$0.78

Note that it is unlikely that a high seed yield will be received in a year of below average grazing, therefore some of the lower cost figure may not apply. The figures are only provided as an approximate guide for producers who may wish to consider all of the costs of setting aside a paddock of butterfly pea for seed collection. The final cost will depend upon the combination of the above factors in each particular paddock harvested.

What does it mean?

A number of local producers have reported seed yields between 200 - 600 kg/ha for paddocks kept aside for butterfly pea seed. At this range of yields, the cost of producing their own butterfly pea seed appears quite reasonable (relative to purchasing seed from an external supplier). However no allowance has been made for the time spent by the manager in organising the whole process.

18. Modelling the effect of soil nitrate decline on potential farm profitability

Why was the work done

The decline in soil nitrates under Central Queensland cereal farming systems will reduce farm profitability over time. Deciding by how much and by when is complicated by a number of factors including the effect of seasonal variation, the cost of fertiliser and the cereal cropping intensity.

To provide some insight into the effect of soil nitrate decline, an estimate of the cost to a representative cereal cropping enterprise was calculated by modelling a range of cereal cropping systems in APSIM using 100 years of Capella or Biloela weather data.

How was the work done?

APSIM was configured to start cropping sequences with soil nitrates set at three levels. The first level was similar to that found in a "new" soil that had not been cultivated previously. The second was set at a level of nitrates expected to remain after thirty years of farming. The final level started with residual nitrates equivalent to the effect of 50-60 years of farming.

Each nitrate level was modelled as being farmed for eight overlapping thirty-year climate sequences. Crop gross margins were calculated for each crop grown in each sequence and applied to a representative farm model.

What happened?

Figure 27 shows the expected decline in farm business performance due to the extraction of soil nitrate by a summer dominant, low intensity cereal farming system at Capella in Central Queensland as modelled by APSIM. Cereal farming systems modelled at Biloela showed a similar rate of decline.

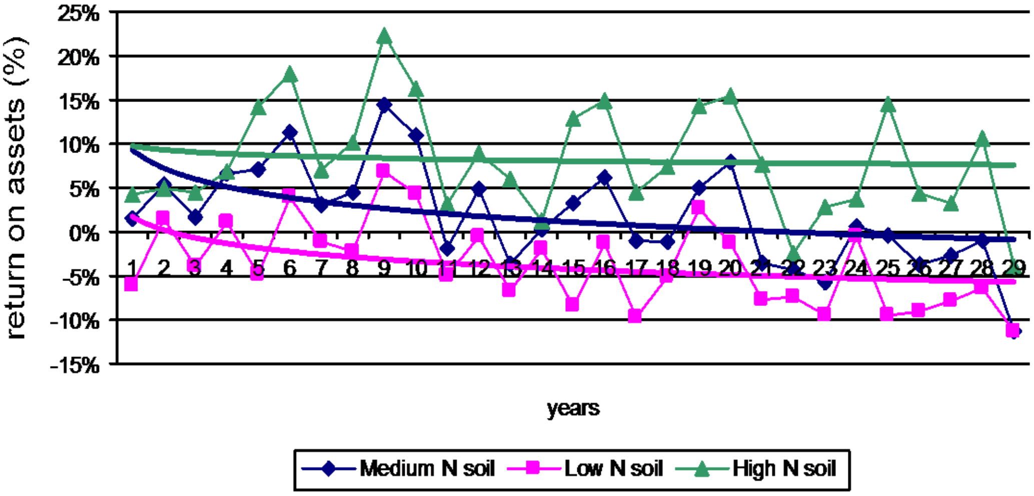


Figure 27 thirty-year trends in return on assets for a representative farm business at Capella growing sorghum without nitrogen fertiliser. Each trend line is the average of eight climate cycles modelled in APSIM starting at 1900. Each dot point represents the annual soil nitrate reading as measured by APSIM.

Over the first thirty years of farming the return on assets trend is little affected by the underlying soil N decline. During the next thirty years the performance is noticeably reduced. During the final thirty-year period no farm business would survive without adding fertiliser N to cereal crops.

What does it mean?

The return on assets over time for any of the representative farm models showed a high degree of variability. As costs and returns are kept constant for each period of the analysis, most of the variability is driven by the climate of Central Queensland.

While it is clear that farm performance declines dramatically over time as soil nitrates decline, there are no clear indicators from this form of modelling as to when a fertiliser strategy of any nature could be profitably implemented for cereal cropping.

19. Calculating the cost per ha of accessing a precision planter

Why was the work done

Many Central Queensland dryland farmers currently own planting equipment that is not suited to precision planting of summer crops under zero till conditions. As the failure to correctly place and space the seed of summer crops in this environment can cause a yield penalty of up to 50%, some difficult decisions have to be made.

A common choice is to either purchase an additional planter that meets their needs or access a contractor who can successfully plant crops for them.

The cost of accessing either of these options will be an important part of the decision. To make a sound decision it is important to include all of the relevant costs and use an accurate method of calculation. Calculating the economic cost per hectare after tax and inflation have been accounted for could allow a more accurate comparison of costs to be made.

The economic cost of owning a planter includes such things as repairs and maintenance, depreciation, insurance plus the opportunity cost of the capital tied up. Some of these costs increase with inflation over time (eg repairs) others are fixed for the life of the machine once it is purchased (eg depreciation). Taxation offsets or a machine that maintains its market value can reduce the economic cost of ownership.

To illustrate the range of costs and the breakeven level, an example of the result of calculating the economic cost of accessing a zero till precision planter under Central Queensland conditions is presented.

How was the work done?

Information was collected for the expected costs of operating a twelve metre wide zero till precision planter over a ten-year investment life in Central Queensland. The total annual costs of ownership were converted to costs per hectare for a range of crop areas planted per annum.

These costs were compared to the expected cost of accessing contract planting services. As the availability of contract services may be in some doubt at planting time, an allowance was made in the calculations for the expected effect of reduced timeliness of contract operations.

What happened?

Figure 28 shows the range in the final cost per hectare of zero till precision planter ownership. A range of investment values has been used, as the initial cost of the planter is largely an unknown.

It can be seen that the cost per hectare of accessing precision planter technology declines rapidly with the number of hectares planted each year.

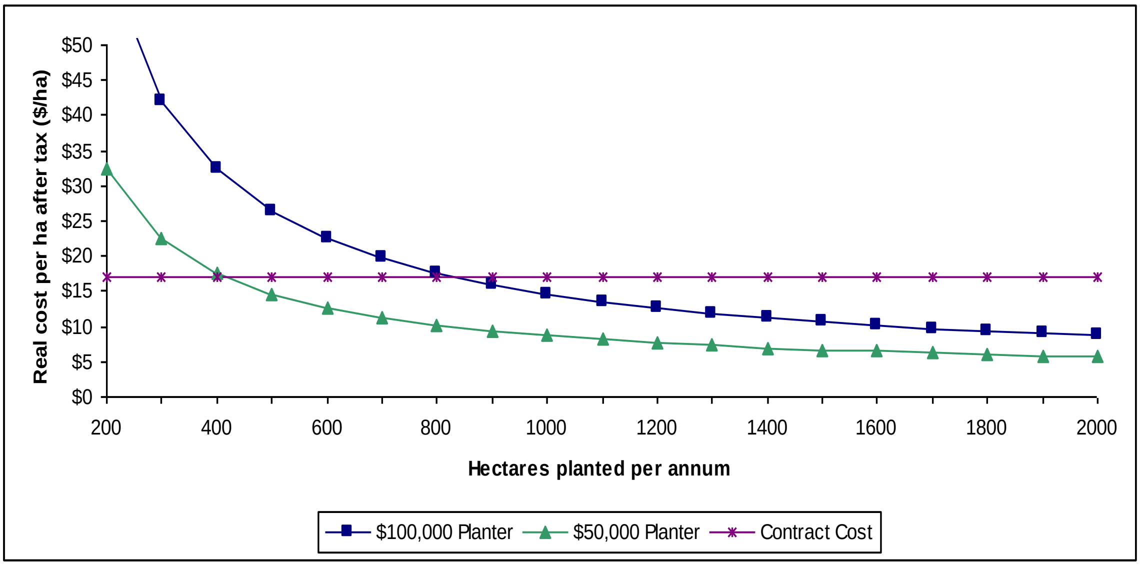


Figure 28 Real cost per hectare after tax of accessing twelve metre precision planter technology with different levels of capital investment.

What does it mean?

This example applies to a 12m planter, its normal work rates and costs.

If areas of 500 ha or less are planted to summer crops each year, then it will probably be less costly to hire a competent planting contractor than to purchase a suitable precision planter.

If more than 1000 ha per annum is to be planted to summer crops, then it is possible that a suitable precision planter with a capital cost somewhere around $100,000 will be less costly that hiring a competent planting contractor.

For areas between 500 ha and 1000 ha per annum of summer crop it may be better to initially contract plant a number crops until a suitable planter is identified, then consider the decision in the light of cropping returns and farm profitability at that time.

Calculating the economic cost of a zero till precision planter does not indicate whether the investment will be the best use of the funds. Neither is any account taken of the possible effect on farm cash flow of financing the new planter. Considering only the cost of a new piece of equipment may not always provide sufficient information for a good decision to be made, but it is a starting point.

APPENDIX 2

Farm management economics and biological modelling in farming systems research

Brennan and McCown (2001) provide a complete synopsis of the current state of farm management economics and systems modelling within farming systems research (FSR) as it is carried out within Australia.

They have identified some important areas in FSR where modellers and farm management economists could become involved. We have summarised them as follows:

- Where the challenging problems of unsustainable farming systems are engaged by FSR,
- Where a process of dialogue and interaction is needed with farmers to represent their management system in FSR processes,
- Where the value of farmer experience is greatly reduced by a highly unstable climate,
- Where farm budgets are being used by scientists in a nonsensical way,
- When a farmer is a novice regarding a practice,
- When a relationship between action and outcome breaks down,
- When there is a radical change in technology,
- When there is a radical change in strategy and;
- Where on-farm experimentation cannot adequately address the problem.

We agree that these areas could be more adequately addressed within Australian FSR if modellers and farm management economists became involved.

Brennan and McCown (2001) recommend this involvement include a shift in research typology from policy research to action research so that farm management economists and modellers begin to work at the interface between the research and the farming problem. The tools to be used at this interface include:

- the traditional budgeting techniques of farm management economists,
- situated, simulation aided discussions with farmers that use hard systems models and,
- case study methods.

Our experience is that the incorporation of simulation aided discussion and the use of traditional budgeting techniques do provide strong support for FSR activities.

For us, the critical factors for successfully "reinventing" and "resuscitating" farm management economics plus combining it with biological modelling within FSR seem to be:

- incorporating modelling and economic activities and personnel during the planning process at the beginning of a project,
- allowing some scope within the project for the activities of the economist and/or modeller to be developed as issues unfold,
- budgeting some time for farm management economists and modellers to work with individual farm managers within the project in an action research mode,
- recognising farm management economists/ farming systems modellers as a very scarce resource that is likely to become more scarce if current trends continue and,
- providing secure funding within major FSR projects for modelling and economic activities.

The experience of the CQSFSP team is that a successful integration of farm management economic and biological modelling components can enhance project activities and outcomes.

Although we strongly agree, that "within a dynamically evolving FSR, a resuscitation of farm management research might be desirable and feasible" (Brennan and McCown 2001), there appear to be considerable impediments to progress.

Only a relatively small number of either academic or non-academic agricultural economists are funded or choose to work in the area of farm management economics. Very few of these are employed to work predominately in farm management economics as it applies to FSR. Competent users of complex biological and simulation models are equally rare.

Farming systems research in Australia has had and still has a technical focus. Quite often the agenda for how individual farming systems projects are to be progressed is generally set within the rigid technical framework of traditional agricultural science with little reference to the role that may played by a farm management economist and/or a systems modeller. This is very different to the situations and systems that helped develop and make FSR successful in lower income countries during the 1960's and 1970's. (See Norman 2000) The social sciences have played and still do play a major role in successful FSR outside of Australia.

Where there is a highly technical structure of FSR, a key effort by the farm management economist can be to explain:

- the nature of farm businesses and farm management,
- why there is a gap between the optimal use of farm resources and the actual use of farm resources,
- why worrying about the gap is sometimes not very important and,
- why it is important to remember in FSR that "economic ways of thinking by management link the many diverse components that determine the outputs of a farm business" (Malcolm 1990).

This area of effort can add considerably to the progress of the FSR project but can also dilute the interaction of the farm management economist with the farm managers themselves.

In some projects it has been decided, sometimes unilaterally, that the highest priority for the farm management economist is to complete some form of comparative analysis of farming systems. Unfortunately, this is often also seen as an end point to the activities of the farm management economist within the project. (See Ferris and Malcolm 1999 for an excellent critique of this inappropriate technique)

Although Brennan and McCown (2001) see the reinvention of farm management economics occurring within farming systems research as being a logical consequence of the need to make farming systems research effective in supporting farm management practice, considerable specialist resources have to be made available to any FSR project if a reasonable level of involvement is to be maintained and the tools of modelling and farm management economics used effectively.