Application of Soil Monitoring, Benchmarking and Crop Simulation in Commercial Dryland Cotton Management

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ABSTRACT

Many agronomic decisions involve risk as many of the factors involved are unknown or uncertain (e.g. rainfall). History can often serve as our best guide to the potential risks and benefits of a particular strategy. The use of crop simulation models is a powerful, and often the only, way to address such issues. Participatory research approaches were used to address key issues in dryland cotton management through on-farm trials, crop and soil monitoring, and simulation modelling (OZCOT and APSIM). Model credibility was established through simulation sessions with small groups of farmers. Subsequently the results provided farmers and consultants with information on their soil, benchmarked performance of commercial crops, and provided an assessment of the impact and risk of their management decisions within the context of the whole climate record rather than a single season. The results were also provided to other farmers and consultants through established networks. Future studies aim to investigate the more efficient means of delivering systems simulation to industry.

Introduction

Australian dryland cotton farmers face increasing pressures with rising production costs in a rainfall environment that is among the world's most variable. Adding to this, farmers face uncertainty about the amount of water and nitrogen that is stored in their soil. Farmers can overcome much of this variability by achieving a greater understanding of their soil and linking this information with crop simulation models.

Simulation models can predict the performance of crops under different environmental and management conditions. They are a means of easily and efficiently achieving understanding and gaining "experience", without suffering the consequent pain and cost of real-life experience when mistakes are made.

The questions remain as to how well simulation models perform relative to commercial agriculture and how the industry can utilize these tools. Scepticism on the applicability of models is not due to their rarity or lack of exposure. Many computerized decision support systems (DSS) have been developed and/or supported in Australia but farmer acceptance has been disappointing (Cooke, 1994).

The first objective of this paper is to relate the experiences of some cotton farmers and consultants who have benefited from monitoring their soil and crops, benchmarked their cropping system, and applied systems models in their farming operations. The second objective is to describe a recent effort employing a participatory action research approach within the Australian cotton industry towards commercial delivery of systems simulation. This approach has important distinguishing features from past efforts into decision support systems.

Participatory Research

FARMSCAPE (Farmers, Advisers, Researchers, Monitoring, Simulation, Communication And Performance Evaluation) (McCown *et al.*, 1998) is an acronym employed to represent a participatory action research approach that explicitly addressed the question of relevance of systems models to commercial farming. Using an action research approach allows for an evolution of a research methodology rather than limiting understanding and outcomes through undertaking traditional scientific experimentation. In the context of 'farming systems research' hard systems tools (models) have been used in interactions with the FARMSCAPE participants in ways that utilize soft systems methodologies (McCown *et al.*, 1998). The research explores whether any farmer or adviser could gain benefit from tools such as soil characterization and sampling, seasonal climate forecasts and, in particular, simulation modelling and, if so, how such tools could be delivered cost-effectively to industry. FARMSCAPE has been based on the key elements identified in its name:

1) Close collaboration of farmers, their advisers and researchers in groups discovering together how best to explore management options;

2) Implementation of research on farms, especially incorporating improved soil monitoring to gain better knowledge of soil water and nitrogen in individual paddocks;

3) Application of the APSIM systems model (McCown *et al.*, 1996) linked with the OZCOT cotton model (Hearn, 1994) with a requirement that simulations be credible against real-world experience;

4) The broader communication of project outcomes not only through public extension activities but particularly through agribusiness client services, and

5) Continual assessment of project activities and impacts via formal evaluation processes.

Direct working relationships have been established with over 200 farmers and 15 advisers who have influenced research direction and provided strong support for continued evolution of the FARMSCAPE tools and techniques.

Crop and Soil Monitoring

Farmers benefit from understanding their soils and knowing the current status of their soil nitrogen and water availability. This information while initially collected to parameterize and initialize the simulation models has become in itself a valuable source of information for farmers. Participatory research activities involving co-learning between the researchers, farmers and advisers have allowed for the development of robust and inexpensive equipment that allows; simple characterization of the soil with respect to plant rooting depth and plant available soil water holding capacity; and to allow rapid measurement of soil water and nitrogen status at depth (Foale *et al.*, 1997). Farmers use this information to change management practices such as fertilizer rates or crop selection, or to confirm their existing strategies (Dalgliesh *et al.*, 1998).

Monitoring crops is also important in order to establish model credibility and relevance to commercial farming practices. Commercial cotton crops have been monitored and used to test OZCOT simulations (Fig. 1). Most crops where predictions were significantly different, discrepancies were mostly due to impacts of factors not accounted for in the models (e.g. severe pest damage). For many farmers and consultants, APSIM and OZCOT have proved credible enough to be relevant to commercial cropping practices and now use them in benchmarking the performance of their own crops and in exploring alternative management strategies.

Crop Simulation in Commercial Crop Management

Examples of the use of simulation in commercial management follow.

Benchmarking performance of commercial crops

Whether a crop has performed to its potential is often of great interest to farmers. Given actual seasonal climate and management inputs, models are used to predict what a crop should have yielded in the absence of extraneous factors, thus providing a benchmark against which actual crop yield can be assessed. The models are then used as a learning tool to explore other management options that could have been use to better yields in a particular season. If an option is more successful it can then assessed using simulation within the context of the whole climate record rather than a single season.

Strategic decision making

A common and useful application of simulation models is to explore new options or environments as general scenarios that are broadly relevant to a region or group of farmers. An example of this is taken from a group of farmers investigating the potential of dryland cotton production. The OZCOT cotton model was run with inputs generated by the farmers and a local consultant in order to generate risk analyses and gross margins for dryland cotton assuming a full and half a profile of soil water at sowing time (Table 1).

The resultant predictions were mostly consistent with the expectations of both a neighboring cotton farmer and the local consultant. While there was risk, the farmers considered the risk in crop failure was not much greater than that for their other crops. The group discussed offsetting this risk by limiting the area of cotton in relation to their other summer crops. While some growers decided to grow cotton it is important to note that this simulation exercise did not make the decision for the farmers, but merely provided them with another source of information to assess the returns and risk of a new farming option.

Tactical decision making

The APSIM or OZCOT models can be used in planning for the current or upcoming crop. Decisions on crop choice, varietal selection, fertilizer rate, sowing date, plant population, row configuration and so on can be assessed based on knowledge of pre-plant soil water, soil chemical analysis and seasonal climate outlook. Based on this information, the models can provide an assessment of expected crop performance in the upcoming season by simulating what would have happened under these same conditions in past years for which climate records exist. Figure 2 presents an example for cotton planted as either solid or single skip row configuration under low starting soil water conditions. The farmer for whom these simulations were undertaken, changed to single skip cotton in the 1997/98 (El Nino) season rather than his normal solid plant configuration. Another significant advantage of APSIM is that it is a model of a cropping system, able to simulate the production and environmental consequences of different crop rotations.

Learning and Evaluation in FARMSCAPE

FARMSCAPE is a research activity that recognized that in exploring ways in which farmers could better manage their farms, they needed not only to be consulted on the design of what should undertaken, but also to participate in the implementation of the research and the interpretation of its outcomes. In other words, instead of using scientific models to build derivative tools that scientists believed could help farm managers (such as a computerized Decision Support System DSS), base models were taken to farmer and advisers to design and test applications for their own situations. What emerged has been confirmation of the benefits of farmers gaining better knowledge of their water and nitrogen resources through increased intensity of soil monitoring and the discovery of a role for systems models in assisting the management of cropping systems.

Assisting in this learning and steering the direction of the research has been the formal evaluation component of FARMSCAPE. The evaluation process sought to monitor and interpret the project through the eyes of all participants in a longitudinal study. Through iterative interviews of participants this provided an effective mechanism to capture perceptions, learning and management practice changes (Coutts *et al.*, 1998).

FARMSCAPE has helped demonstrate that the key to farm managers valuing simulation is the positioning simulations in the context of their own farming situation. In contrast, many DSS packages provide generic or representative information for a district, depending on plausible answers (as many of their assumptions cannot be tested using one's own data), and many DSS are generally targeted at single or few issues. Another important difference is that many DSS packages have been designed to provide recommendations on what decisions should be taken while FARMSCAPE leaves the interpretation to the farmers, providing a means of learning about their own farming systems.

The Future

Developing the FARMSCAPE approach and tools to the point of commercial delivery is the next step for this research and development activity. A market now exists for timely and high quality interactions based on soil monitoring and simulation amongst a significant sector of the dryland farming community. Formal evaluation of the current FARMSCAPE project has demonstrated impacts on participating farmers and advisers. The demand for simulations has increased rapidly to the point where researchers cannot meet the demand, nor justify providing a "commercial" delivery service. One preferred delivery mechanism is to establish and support an Accredited Adviser Network of agribusiness and private consultants for delivering simulation and related products. Finally, the intention is to continue research on the role for simulation, expanding to include irrigated cotton production systems and include other agribusiness service sectors (bank lenders, crop insurance, product inventory, marketing advice, etc.). An emerging area worthy of further exploration is whether better information on seasonal climate forecasting and cropping prospects can improve institutional decision making.

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References

Cooke P. (1994): Farmers give research wish list. Farming Ahead 26:3

Coutts, J.A., Z. Hochman, M.A. Foale, R.L. McCown and P.S. Carberry. (1998): Evaluation of participative approaches to RD and E: A case study of FARMSCAPE. Pp. 681-682.

Dalgliesh, N.P., N. Olm, N., Douglas and R.I. McCown. (1998): Improving management using soil monitoring and simulation: A case study of co-operative learning. Proc. 9th Aust. Agron. Conf. Charles Sturt Uni., Wagga Wagga. Pp. 791-792.

Foale, M.A., P.S. Carberry, Z. Hochman and N.P. Dalgliesh. (1997): Management of Dry-land farming systems in North Eastern Australia. Agricultural Science. 10:34-37.

Hearn, A.B. (1994): OZCOT: A simulation model for cotton crop management. Agric. Syst., 44:257-99.

McCown, R.L., P.S. Carberry, M.A. Foale, Z. Hochman, J.A. Coutts and N.P. Dalgliesh. (1998): The FARMSCAPE approach to farming systems research. Proc. 9th Aust. Agron. Conf. Charles Sturt Uni., Wagga Wagga. Pp. 633-636

McCown, R.L., G.L. Hammer, J.N.G. Hargreaves, D.P. Holzworth and D.M. Freebairn. (1996): APSIM: A novel software system for model development, model testing, and simulation in agricultural research. Agric. Syst. 50:255-271.

McCown, R.L., P.S. Carberry, M.A. Foale, N.P. Dalgliesh, Z. Hochman and J.A. Coutts. (1997): Decision support for systems: Back to basics in managing crops and croplands in northern Australia. Agronomy Abstracts. Pp. 21.

Table 1. Information provided to farmers to assess risk of dryland cotton production.

Figure 1. Predicted yields versus commercial crop yields.

Outcome	Probability of Achieving Outcome (%)	
≥ Greater than or equal to	Full Profile Soil Moisture	Half Profile Soil Moisture
≥ 1.70 bales/ha (0.7 bale/ac breakeven)	84	78
≥ 2.47 bales/ha (1.0 bale/ac)	63	53
≥ 3.71 bales/ha (1.5 bales/ac)	43	34
≥ 4.94 bales/ha (2.0 bales/ac)	32	22

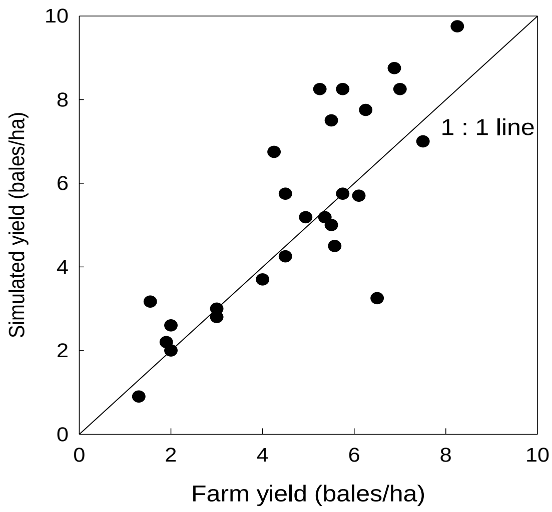
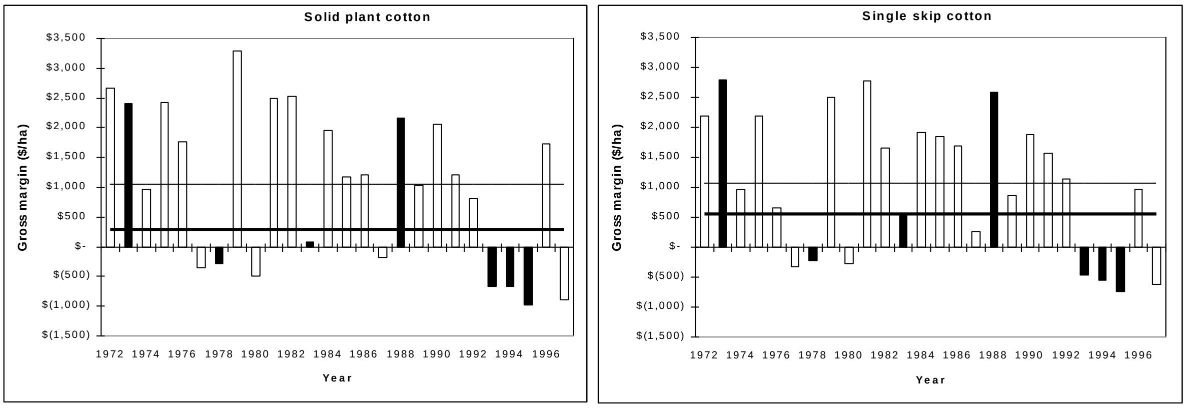


Figure 2. Predicted gross margins for solid and single skip cotton crops.



Solid bars represent *El Nino* seasons, the average for which is represented by the horizontal thick line, the thin line is the average over all seasons