Farming systems models – strategic planning and the economic benefits

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Introduction

> "*A need and a demand for DSSs (Decision Support Systems) have been demonstrated in the Australian cotton industry. In our judgement all stakeholders in the cotton industry, including participating scientists, have benefited from the two decades of DSS work. The DSSs have had a major impact on crop management in the industry, which now accepts DSSs as providing objective standards.*" Hearn and Bange (2002)

Cotton production in Australia is a high-tech industry. Genetically engineered cotton varieties, precision agriculture with self-steer tractors and variable rate applicators, and satellite-generated yield predictions are all indicators of technologies being adopted by the cotton industry. In contrast, debate over the usefulness and useability of computer-based decision support systems (DSSs) and simulation models continues even after 25 years of their development for and promotion to the Australian cotton industry (Hearn and Bange, 2002).

One in five cotton growers and consultants in Australia are reported by Hearn and Bange (2002) to actively use the *CottonLOGIC* DSS in their crop management decision-making. *CottonLOGIC* has been designed to deliver user-friendly software to be run on one's own computer in order to provide information for management recommendations for decision-makers. It is issued free on request to anyone in the cotton industry. How it is being used and its impacts are less clear. Evaluation surveys suggest that one of the main benefits of *CottonLOGIC* is the provision of an industry benchmark and a learning tool for responsible crop management (Hearn and Bange, 2002). The area of cotton managed using *CottonLOGIC* and the economic or environmental benefits from its use are yet to be fully quantified, although such assessment is currently being undertaken.

The debate over whether growers will use DSSs and their usefulness to crop management has accompanied the long history of their development (McCown, 2002). Many of the concerted efforts of delivery of DSS have occurred with cotton, either in Australia with SIRATAC (Hearn and Brook, 1989) or in the USA with GOSSYM/COMAX, (Hodges et al., 1998) and

CALEX-Cotton (Plant, 1997). None of these systems have persisted despite significant investment and promotion by their public sector developers, although elements of SIRATAC have persisted in the CottonLOGIC program.

Is there a market for computer-aided decision support in the Australian cotton industry? And if so, how can it be delivered cost-effectively?

Most cotton growers and consultants in Australia are likely to already have a view on the usefulness of the *CottonLOGIC* system for their own management as they have been given free access and support to this system. While this approach is advantageous in allowing industry participants to trial *CottonLOGIC* and judge for themselves, the distribution of public-supported, cost-free software and backup support services provides little indication of market demand nor does it likely offer a sustainable and cost-effective delivery mechanism. The DSS experience from around the world is testimony to these conclusions (McCown, 2002).

The objective of this paper, therefore, is to describe an alternative application and delivery system for crop simulation technology to the traditional DSS delivery system typified by the *CottonLOGIC* system. In this alternative system, farming systems models are being used as general-purpose simulators by advisers for servicing the management needs of their grower clients – i.e. it is a form of 'simulator-aided farm consulting'. Carberry et al. (2002) described in detail the APSIM model, its application in this mode and its impact as used with growers and their advisers in the northern cropping region. This paper briefly illustrates some examples of how farming systems models are being used by cotton growers in Australia and describes how these tools are being delivered via commercial consulting services within the cotton and grains industries.

The APSIM farming system model

The Agricultural Production Systems Simulator (APSIM) is the world's leading systems simulation model, capable of predicting the performance of cropping systems under variable and risky environments. APSIM has been designed to simulate the growth of a range of crops in response to a variety of management practices, crop mixtures and rotation sequences, including pastures and trees (Keating et al., 2002). An important distinction of APSIM is its emphasis on the soil as the central component, whereby the effects of different agricultural practices such as cropping, fallowing, residue management, irrigation and tillage can be accrued over short or long-term simulations. This permits the simulation of issues such as deep drainage and risk of salinity, soil organic matter rundown, nutrient leaching, soil erosion, soil structural decline, soil acidification and weed competition. Current work is progressing to incorporate the effects of pesticide transport, salinisation, insect and disease incidence and biodiversity loss.

The cotton module in APSIM is based on the OZCOT model (Hearn, 1994), which has been widely tested and used within the Australian cotton industry (Bange and Marshall, 2001). APSIM-OZCOT captures the capability of the stand-alone OZCOT and allows it to be applied in a cropping system environment (Carberry and Bange, 1998).

The FARMSCAPE approach to decision support intervention

FARMSCAPE (Farmers', Advisers', Researchers', Monitoring, Simulation, Communication And Performance Evaluation) is a program of participatory research run with grain and cotton growers in north-east Australia over the past 11 years. It initially involved research to explore whether farmers and their advisers could gain benefit from targeted information on soils and climate and, in particular, from simulation modelling. Its current focus is facilitating the implementation of delivery systems for these same tools in order to meet industry demand for their access. Carberry et al. (2002) recently reported the details of the FARMSCAPE research program – what was done over the past decade, performance indicators of impact, reflections on what was learnt over this period and an outline of where this research would likely head into the future.

The key distinction of the FARMSCAPE approach to decision support intervention is the emphasis on using the APSIM systems model to facilitate participant learning through exploration of management options within their own farming system. This represents a distinct shift away from the DSS paradigm of delivering user-friendly software designed to provide integrated, optimal recommendations for management "*as a proxy for a manager's own decision process*" (McCown, 2002). The attraction of the APSIM systems simulator to growers contemplating change is that it allows them to explore their own farming system in a manner equivalent to learning from experience. To achieve this, APSIM had to be credible and flexible and, to date, it has proven to be so to many growers and their advisers. The experience from over 10 years in the cropping regions of northern Australia is that when relevance is appreciated and credibility established by a grower, a versatile simulator often becomes a valued opportunity to conduct meaningful 'what if?' management experiments.

A shift from user-friendly software designed for use by growers to a versatile simulator necessitates that an intermediary be available to run the model. The common use of agricultural consultants in the cotton industry provides a possible market for APSIM used in this mode. Therefore, current efforts are focused on the training, support and accreditation of commercial agronomists in the application of the APSIM model for use with their grower clients.

Case study applications in the cotton industry

The APSIM systems model has been used by many farmers and consultants in the northern cropping region and increasingly in other regions of Australia. A number of these applications, along with farmer reactions, are reported on the www.farmscape.cse.csiro.au web site. Case studies of how three growers are currently using APSIM are briefly presented in the following sections.

Exploring dryland cotton rotations

James Clark is a dryland and irrigated grower at Croppa Creek in northern NSW and, together with his consultant Michael Castor (MCA, Goondiwindi), they have been using APSIM over several years to explore the performance of alternative dryland cropping systems. Nicholls (1997) quoted his rationale on how he has used APSIM:

> *"Developing a better understanding of his soil is one of the greatest benefits from the APSIM model ... Together with his local farm adviser, (he) uses the model to determine realistic crop yields from each paddock at the beginning of the season . He then tailors his management to achieve those yields"*

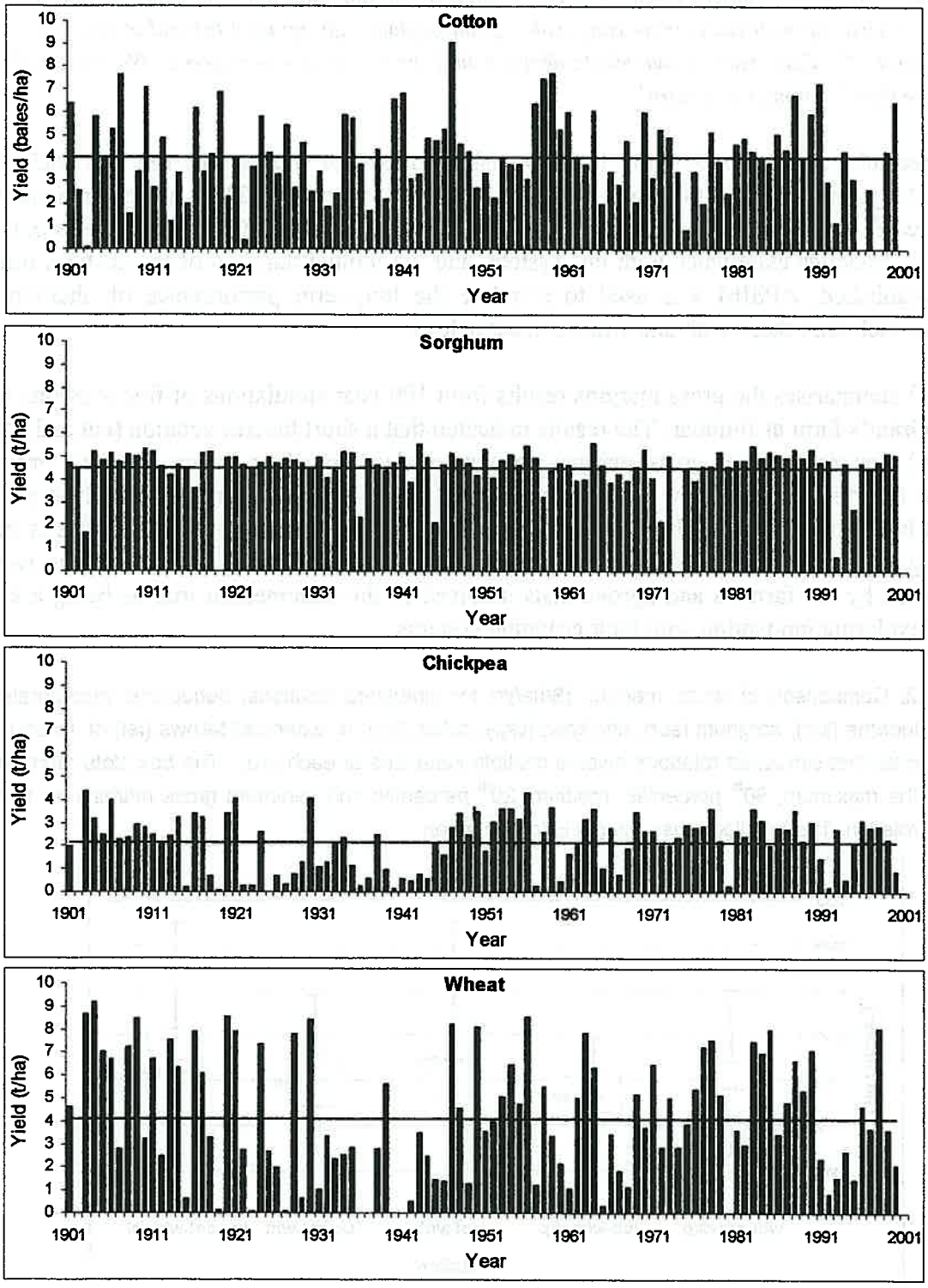
APSIM applications of particular interest have been the exploration of alternative crop rotations which best fit local soil and climate resources and their management objectives. His current dryland rotation is a four-year rotation of long fallow into cotton, short fallow to sorghum, double crop chickpea and, finally, short fallow into wheat – both the cotton and sorghum crops are grown in double skip row configurations. Example simulated yields for this rotation over 100 years (1901-2000) are presented in Figure 1. Such APSIM simulations, using Goondiwindi climate records and soil data characterised specifically for the Clark farm, permitted not only the comparison of crop yields and gross margins for a range of rotation and management options but also accounted for other performance criteria such as risks of crop failure or soil loss from erosion.

MCA is a current licensed and accredited user of APSIM and has the capacity to perform such analyses for their grower clients. James Clark continues to explore his system using APSIM. His current interests in using APSIM extend to investigating the role of other crops in the rotation (eg. maize and mungbean) and in assessing how seasonal climate forecasts may be employed in his farming system.

Exploring new cropping systems

Jamie Grant is a dryland grower on the Jimbour plain near Dalby. Together with neighbouring farmers and Wesfarmer Landmark agronomists, he has been an active user of APSIM simulations to explore the performance of his system over a number of years. Lloyd (2000) reported the outcome from one such APSIM application on Jamie's farm:

Figure 1. Simulated yields for a long fallow cotton – sorghum / double crop chickpea – wheat rotation over 100 years at Croppa Creek, NSW. The horizontal lines represents the mean yields.

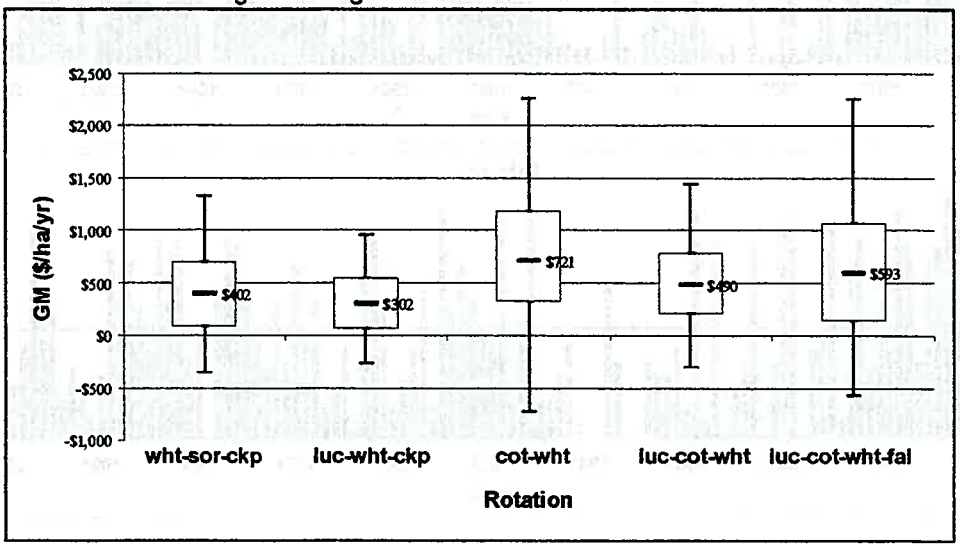


"Two years ago when he wanted to plant corn but his country remained wet until mid October, he thought he had missed his chance. "But when the APSRU people did some runs on the model, given the Southern Oscillation Index (SOI) at the time and our soil moisture, and the model came up with yields increasing with a planting date right up until the end of October," he said. "So that changed our whole decision and the result was very good. We averaged more than 7.5 tonnes a hectare."

More recently, a group of Jimbour farmers wished to explore whether lucerne leys could be successfully integrated into their intensive cropping rotations. They were particularly interested in the impact of lucerne on soil structure, rainfall capture and soil water storage. Given no previous experience with this system, and the limited duration of the on-farm trials they established, APSIM was used to simulate the long-term performance of alternative systems, including those with and without lucerne leys.

Figure 2 summarises the gross margins results from 100 year simulations of five rotations for Jamie Grant's farm at Jimbour. The results indicated that a short lucerne rotation (cut and sold for hay) returned lower gross margins than equivalent cereal or cotton rotations grown without lucerne. A long fallow cotton, double crop wheat rotation returned the highest gross margin but also included the highest risk. While the impact of lucerne on soil structure is still to be quantified through on-farm trials (Dalgliesh et al., 2000), APSIM simulations were recognised by the farmers and agronomists involved in this commercial trial as being a key tool in exploring innovation with their cropping systems.

Figure 2. Comparison of gross margins ($/ha/yr) for simulated rotational sequences incorporating lucerne (luc), sorghum (sor), chickpea (ckp), cotton (cot) or extended fallows (fal) at Jimbour – note that simulated rotations involve multiple instances of each crop. The box plots represent the maximum, 80th percentile, medium, 20th percentile and minimum gross margins for each rotation. The labelled gross margin is for the mean.



Agronomists at Wesfarmer Landmark, Dalby, have been licensed and accredited to undertake APSIM simulations and they currently offer this service to their farmer clients.

Exploring irrigation options

The grower group, Darling Downs Vision 2000 (DDV2000), is actively lobbying to gain access to effluent water from the Brisbane City Council. The economic and environmental consequences to growers on the Darling Downs receiving this new source of irrigation water will be an important component of any decision-making process for governments and industries supporting this scheme. APSRU has been commissioned by DDV2000 to use APSIM to explore such consequences for 10 case study farms on the Darling Downs. One of the case study farmers is Murray Ritter, a grower who farms 855ha at Bongeen, Qld., of which 693ha is currently used for rainfed cropping and 162ha for cotton irrigated through the capture of overland flow into a 1200 ML ring tank.

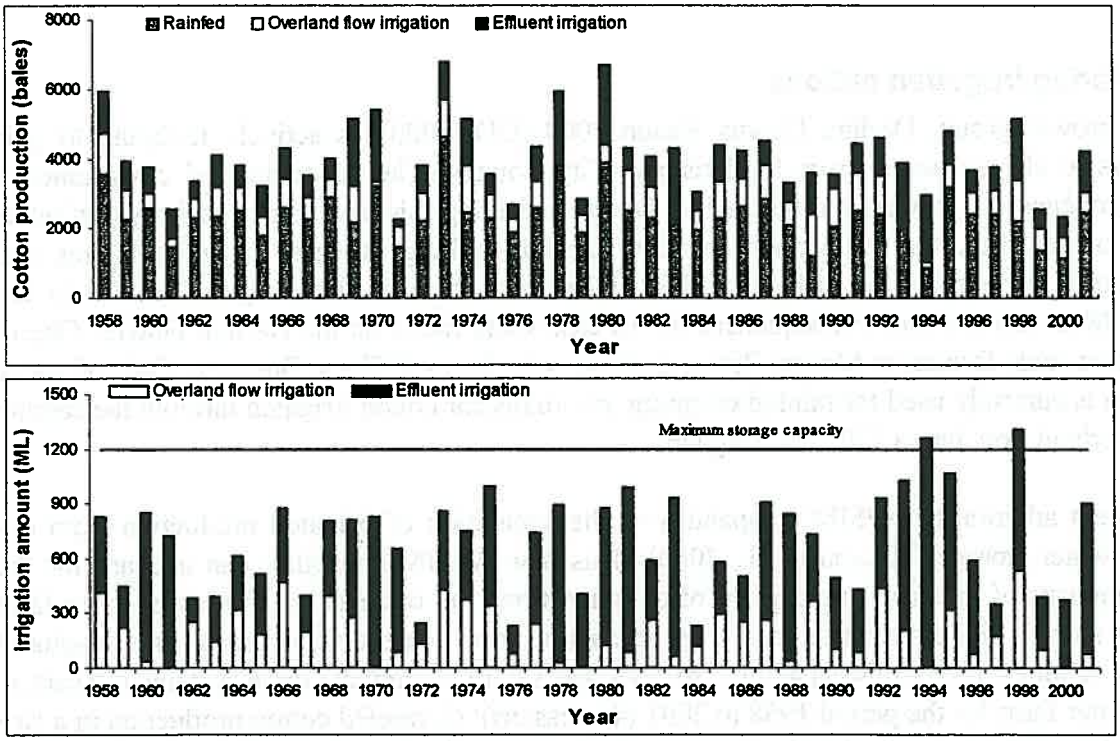
A recent addition to APSIM's capability is the simulation of irrigated production from on-farm water storages (Lisson et al., 2000). This new APSIM capability can account for the mechanisms of opportunistic capture of overland flow, the water gains and losses in on-farm water storage and distribution, and crop production from scheduling irrigation from captured water supplies. Using this capability, APSIM was set up to simulate three systems relevant to the Ritter farm for the period 1958 to 2001 (44 seasons): (i) rainfed cotton production in a two year, long fallow cotton, double cropped wheat rotation for the whole 855ha, (ii) the current mix of rainfed cotton on 693ha and irrigated cotton on 162ha, using only overland flow water, and (iii) rainfed cotton on 531ha and irrigated cotton on 324ha, using both overland flow and 1000 ML of effluent water supply.

Preliminary results from the simulation analysis are presented in Figure 3. Adding the current overland flow irrigation capacity was simulated to increase cotton production from the farm by an annual average of 692 bales over a solely rainfed cotton production system (an average increase of 29%). By buying effluent water and increasing the area of irrigated cotton, farm production was simulated to increase on average by a further 997 bales per year (a 42% increase).

The additional 1000ML supply of effluent water was well utilised within the proposed system with an average annual usage of 696ML applied to 324ha (Figure 3). In contrast, the average water use was only 197ML on 162ha when supplied solely from an unreliable source of overland flow.

The results presented in Figure 3 demonstrate how APSIM can be utilised to explore new irrigation opportunities and strategies for cotton production in the farming system. However, they are still preliminary and incomplete given that a full economic analysis of the three systems needs to be completed to assess the potential value of the effluent water scheme.

Figure 3. Simulated annual cotton production (bales) and irrigation water applied (ML) for a 855ha mixed dryland and irrigation farm at Bongeen, Qld.



Commercial delivery initiatives

To responsibly use a versatile simulator such as APSIM to mimic complex systems in ways that influence farmers' business actions, the user must have high-level knowledge of APSIM's operations and science. Such requirements clearly limit the number of people qualified to use APSIM in this mode. However, agribusiness and private consultants already fill an important role in advising farmers on the tactical and strategic management of their farming operations. The challenge, therefore, is to be able to cost-effectively transfer sufficient capability to these advisers to enable them to utilise APSIM in their business systems in a manner that captures its benefits.

In 1999, a program to train and accredit agronomists from four agribusiness companies to use APSIM in servicing their clients in the northern grains/cotton region was established. This was the FARMSCAPE Training and Accreditation Program, supported in part by GRDC. Formal training modules were developed and offered to cover six competency areas:

1. Soil monitoring and data management: principles, techniques, and quality assurance
2. Weather monitoring and data management: principles, techniques, and quality assurance

3. APSIM: the science, the program and derivative products (eg. Whopper Cropper)
4. Simulation applications in farm management
5. Analysis of simulation results and quality assurance
6. Flexible representation of results and communication with decision-makers.

Accreditation could be conferred separately in 'Soil and Weather Monitoring' (Modules 1 and 2) and in 'Crop and Cropland Simulation' (Modules 3-6).

An advertisement for the program attracted expressions of interest from eight commercial companies ranging in size from large national agribusiness firms to a tender from a single independent agronomist. Of the eight applicants, four companies were selected to nominate agronomists to become trained and accredited in using APSIM to support farmers' learning, planning and decision-making. The participating companies are Wesfarmers Landmark, Hassall & Associates, Michael Castor & Associates and Ward Agriculture. The four selected companies have each contributed funding and allocated staff to participate in the program. The formal training was completed in June 2002.

In 2002, negotiations on a business plan for a national delivery system for APSIM simulations targeted at farmer clients are proceeding with a consortium of agribusiness companies. This initiative was first mooted and is now being designed, promoted and will be financed and implemented by the agribusiness consortium. The business plan proposes that access to the APSIM simulation software be supplied via an internet web site. Growers will access this service via their agronomists who need to be licensed and trained (Level 2) to enable them to specify data inputs for APSIM and to interpret simulation results. Level 2 training will not include a requirement to learn how to run APSIM but rather provide instruction on data input requirement for APSIM and on interpretation of simulation output. Simulation requests submitted via the web site will be undertaken by Level 3 trained consultants. Initially, the accredited agronomists from the FARMSCAPE Training and Accreditation Program will likely fill the role of Level 3 trained consultants. Revenue for the system will be generated via the licensing of Level 2 agronomists and a fee per simulation arrangement. It is hoped that the system will be operational in a pilot phase by the end of 2002.

Conclusions

To return to our starting question, is there a market for computer-aided decision support in the Australian cotton industry? Two current initiatives are actively addressing this question. The *CottonLOGIC* software represents an industry-supported effort aimed at assisting in the management of cotton farming systems. Through tools such as *EntomoLOGIC* (Deutscher and Plummer, 1998) and *NutriLOGIC* (Deutscher et al., 2001), *CottonLOGIC* provides a framework to store information about cotton management that can be used for decision-making. *CottonLOGIC* is a computer-aided decision support system that is being used by growers and consultants to assist their decision-making.

In the second alternative initiative, Carberry et al. (2002) suggests that a market has developed amongst growers for timely and high quality interactions based on farming systems simulation, and that such simulations can be delivered through commercial advisory services. Four commercial advisory companies have been trained to offer simulation as a service to their grower clients, but it is too early as yet to describe how each will implement such a service and whether it represents a successful delivery approach. Likewise, current commercial plans for a national delivery system via the internet demonstrates market interest but not as yet market penetration. These proposed commercial delivery systems are well aligned with the need for simulations to be contextualised to the requests and circumstances of individual growers.

For either initiative, the important test for applicability of computerised decision support will be the industry response to commercial application of these tools. Their routine commercial application is a goal which remains to be realised.

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