# GET REAL, GET DIRTY:
# HOW DO MODELS RELATE TO REALITY?

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While among researchers simulation models are consider to be useful tools, modelling has a bad reputation in the industry. Many people feel it has very little connection with what happens in the field. Part of the problem is a misunderstanding of how models are developed and what sort of information we can expect to get from them. In this paper I will consider some of the steps we go through in building a model and what we can do with them. I will also give an outline of the CERCOT model currently under development at the Australian Cotton Research Institute.

## How Do You Build A Model?

Dynamic simulation models are not developed by sitting in an office and dreaming up how you think a plant works. In its most general sense, a scientific model is something which we use to help us understand or describe something else. For example, fertiliser response curves are relationships (models) that summarise how we expect a crop to respond to fertiliser under a given set of conditions. Dynamic simulation models are built up in a structured way from more simple relationships of how crop growth processes work and respond to the environment. They integrate our knowledge of how we understand the crop to grow and develop as derived from experiments and if necessary supplemented with expert knowledge from people who have worked with the crop for many years.

The first step in building a model is to decide the level of detail at which you wish to work. Plant growth can be considered at different levels. At the most detailed level, we could describe biochemical and biophysical processes. In our models we look at the crop level, but break up each process to a sufficient level of detail so that the responses of each component process are reasonably consistent under a range of conditions.

Sometimes we have good experimental data to describe a process and it is well understood. For example, light interception by leaves has been studied extensively for a large number of crops, including cotton. The data is readily available to provide the relationships to calculate what proportion of the incoming sunlight will be absorbed by a cotton crop with a known amount of leaf.

"Today I have a profile ¾ full of moisture and have just had planting rains. It is a bit early. Should I sow now or wait? How likely am I to have another sowing opportunity? What yield trade-off can I expect if I sow now?"

"Is it worth putting another irrigation on this crop?"

"I have a good planting opportunity for a winter crop. Should I plant wheat now or wait to sow cotton next summer?"

To answer these sorts of questions requires input from both the producer and someone who understands the model and its limitations. It also needs to be timely, and to get maximum value, interactive. The input from the producer will be information on soil type, soil nitrogen status, water holding capacity, water status, specific problems and so forth. The more accurate the information from the producer the more reliable will be the model output. It is important to emphasise here that this is decision support and there is not necessarily a right answer. We cannot predict the future, neither the weather nor commodity prices. What we can says is: given the available climatic data the likely outcome is Y and give some idea of the variability of the likely outcome. What decision a producers makes will depend on their personal attitude to risk and a range of other personal and external factors. These will include considerations of their overall farm plan and production strategy, and external factors such as how well they know their bank manager (resource availability).

A project incorporating decision support of this nature is currently being conducted by the Agricultural Production Systems Research Unit (APSRU) in Toowoomba; The Farmscape project. Mike Bange of the Cotton Research Unit is involved in the Namoi Valley and Liverpool Plains component of this project funded by the CRDC.

## So, What is CERCOT?

*Structure:*

CERCOT is being developed from a marriage of OZCOT, developed by Brian Hearn (1994), and components from the CERES group of models developed in the United States. The model has been constructed using a 'top down' approach. That is, we try to keep it as simple as possible but include sufficient detail to answer the questions we want and to be adequately robust over the anticipated range of applications

The main environmental inputs are daily weather data, soil characteristics and initial soil status. A soil water balance and soil nitrogen balance simulate the daily supply of water and nitrogen to the growing crop. The model simulates the development of leaf area which is then used to intercept sunlight and thus produce dry matter. The simulation of the fruiting dynamics is dependant on an adequate supply of dry matter being produced by the plant to sustain the potential production of fruit. Each of these processes is affected by the weather and the supply of water and nitrogen from the soil.

*Important features:*

CERCOT retains the fruit model used in both Siratac and OZCOT. The fruiting model has been thoroughly validated in both these applications. This is the heart of the model. From the point of view of yield development, the other plant processes can be thought of as providing inputs to the fruit model. The carbohydrate and nitrogen demands of the developing fruit also affect the resources available for vegetative growth and the production of new fruiting sites. It also gives us the ability to explore issues of pest management.

The key area where CERCOT advances from OZCOT is in modelling nitrogen. OZCOT handled plant nitrogen in a robust but simple way. It had no capacity to model nitrogen transformations and movement in the soil. CERCOT has been linked to an explicit soil nitrogen balance that models nitrogen dynamics in response to fertiliser application, weather, soil water movement and crop extraction. How the plant distributes and uses its nitrogen is also modelled. Combined with the improved soil water balance this should allow better simulation of the interaction of water and nitrogen supply on crop growth and yield.

The new soil water balance has a better capacity to reflect the affects of different soil types on the ability of a crop to extract water from different soil layers. This will improve the way the model handles soil types and will also allow specific issues which affect root growth and water extraction, such as soil compaction and row spacing, to be taken into account.

*Proposed Uses of CERCOT:*

CERCOT is expected to replace OZCOT in the areas where that model is currently in use. These uses include the decision support work being conducted by APSRU and a series of strategic studies being conducted by Mike Bange. The model will also be used to extend the experimental results a CSIRO project exploring dry season production of cotton in the Ord.

*Future Developments:*

Work is currently under way to include new capabilities in the model. The two most significant of these are improved differentiation between short and long season cultivars and a capacity to deal with skip row cotton. We are also working toward a capacity to simulate some aspects of fibre quality.

## Conclusion

So, how do models relate to reality? Each step in the development of a dynamic simulation model requires the input of real data: In deriving a way to simulate a process, in testing these components and in testing the model as a whole. Only when we are confident of the ability of the model to mimic the performance of the crop in the field do we begin to use it in practical situations.

Models have already made real contributions to the industry in pest management and agronomy. CERCOT will broaden our modelling capability and future developments will further broaden our scope to deal with key issues in cotton production.

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## References

Godwin,D.C., Wells,A.T. and Hearn,A.B. (1992) Modelling nitrogen dynamics in cotton cropping systems. *In:* Proceedings of the 1992 Australian Cotton Conference, 103-109.

Hearn,A.B. High prices and low rainfall: A recipe for frustration or an opportunity for a calculated risk? *The Australian Cotton Grower,* **16:** 20-28.

Hearn,A.B. (1994) OZCOT: A simulation model for cotton crop management. *Agricultural Systems,* **44:** 257-299.

Humphreys,E., Freney,J.R., Constable,G.A., Smith,J.W.B., Lilley,D. and Rochester,I.J. (1990) The fate of your N fertiliser. *In:* Proceedings of the 1990 Australian Cotton Conference, 161-164.