Software Tools for Learning and Decision Support

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Abstract: Five model-based tools, and how they improve agricultural decision-making, are described. Their role in education is also discussed. Simplified models such as these have some advantages over more complex models, including the not-so-obvious benefit of *not* presenting a comprehensive and detailed set of results - a *fait accompli* in which there is no room for personal bias or experience. Simplification and specialisation can offer some real advantages in modelling tools.

Keywords: Decision support systems; HOWWET?; HOWOFTEN?; PERFECT

1. INTRODUCTION

A number of single-issue decision support tools were developed as a result of a need for simpler products derived from more complex models. These tools may be based on the science used in more complex systems models or on simple rules of thumb. Despite, or perhaps due to simplification, they are effective for their designed purposes.

Our hypothesis is that simple, single-issue, decision support tools or models have several advantages over larger models including speed and cost of development, accessibility, ease-of-use, and transparency. Disadvantages include less comprehensive representation of processes, less flexibility, and reduced ability to include complex interactions. We do not propose that all decision support tools should be made simple or less comprehensive but rather that there is a need for tools and models with a range of complexity. The tools presented cover some of this range.

2. DECISION FRAMEWORK

We use a framework in which decisions are based on two types of information; (i) the current status of the system, and (ii) expectations of future changes in the system. *Current status* might be available soil moisture, nutrient status or commodity prices and *future expectations* might be a seasonal weather forecast. Decisions might include; fertiliser rate, crop choice and crop area.

The relative value of knowing the current status and future expectations requires detailed analysis. Figure 1 shows some of the factors involved in decision making in a dryland cropping region where stored soil water is an important element of production.

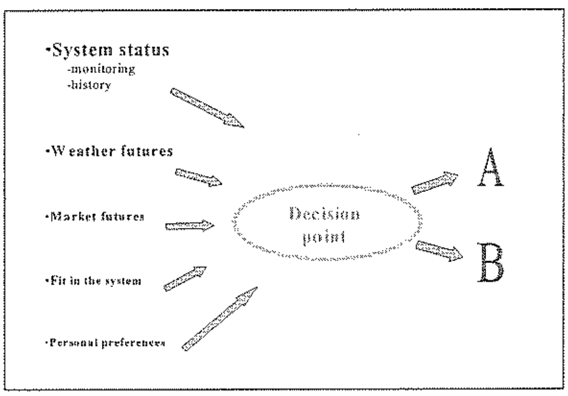

Figure 1. Factors involved in many agricultural decisions in the northern cereal region.

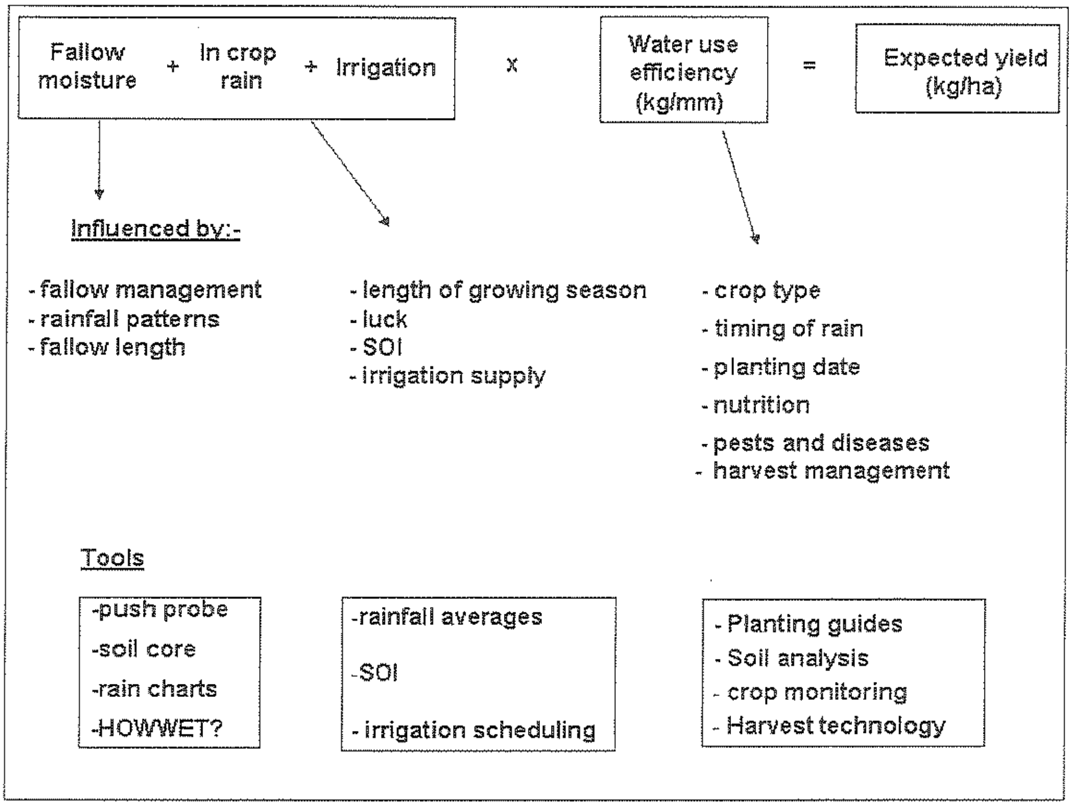

Figure 2. Diagram of the water use efficiency framework, showing factors that influence the main elements, and decision aids that may improve knowledge of these elements.

3. SOME CONCEPTS AND DECISION SUPPORT TOOLS

3.1 Water Use Efficiency

Water Use Efficiency (WUE) is a simple conceptual model for either predicting crop yield or as a benchmark for evaluating crop performance after harvest. Figure 2 shows the WUE framework, and factors that influence production and relevant tools. WUE, based on a model proposed by French and Schultz [1984], assumes that water supply is a major factor in crop performance, and that water supply can be estimated from fallow water storage and in-crop rain. We use WUE as a key in the decision framework

WUE is a robust concept, useful both as an explanatory tool (Figure 3), and predictively to estimate changes in yield associated with management decisions. For example, it is quite easy to estimate changes of yield and profit resulting from extra water stored during the fallow.

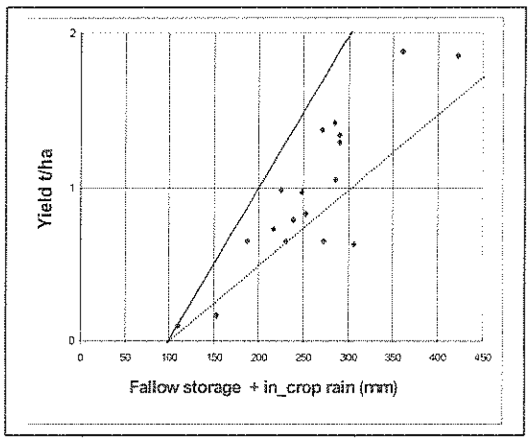

Figure 3. The relationship between yields and water supply (assumed equal to 20% of fallow rain + in-crop rain) for Walgett Shire wheat yields. The solid and dashed lines are for a WUE of 10 and 5 kg/ha/mm respectively.

3.2 Estimating water storage

In Queensland's variable climate, stored soil moisture is the resource that ensures crop yields remain consistent in spite of erratic seasons. Therefore, soil water is an important part of the current status equation. To measure soil moisture, farmers typically use a push probe (a steel spike pushed into the ground to measure how far rainfall has penetrated). Thus their language for soil water conditions would be in terms of "depth of wet soil".

There is a mismatch in units/terminology between farmers and scientists who talk about mm of plant available water. What farmers understand is depth of rainfall in mm. The linkage between the two terminologies is the concept of describing soil water as an equivalent depth of rainfall. For instance, fallow efficiency refers to the percentage of rainfall that is stored in soil over a fallow period. As a result of experiments where soil moisture was measured, a simple rule of thumb has been developed namely, that 20% of fallow rain is stored in the soil. This rule of thumb is probably the simplest model for estimating stored soil water.

3.3 HOWWET?

HOWWET? is a program that uses farm rainfall records to estimate daily evaporation, runoff and soil moisture (Freebairn et al., 1994). Soil organic carbon is used as a parameter to estimate gains in plant available nitrogen mineralised from the soil organic pool. HOWWET? presents soil-water and nitrogen interactions as tables, graphs and an animation (Figure 4). Howwet? supplements other methods of estimating soil water and nitrogen status such as push probing, soil cores, and chemical analyses of soil. It has been used successfully in education and as an aid for fertiliser decisions.

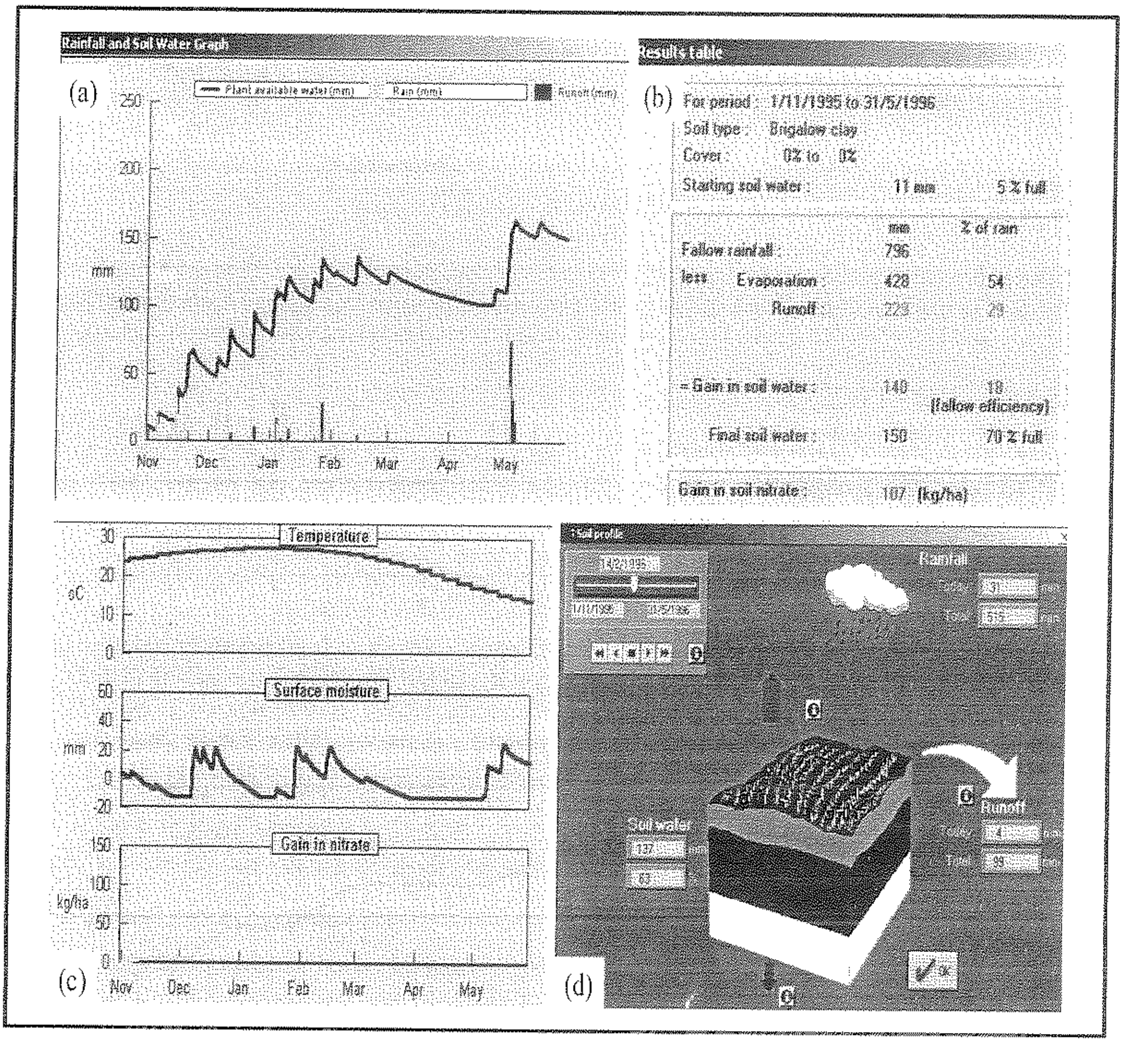

Figure 4. Screens captured from HOWWET? showing output as figures, tables and animation; (a) shows soil water-line, rainfall-light column and runoff-dark column (b) summary table, (c) temperature, surface moisture, and nitrogen mineralisation, and (d) animated soil profile.

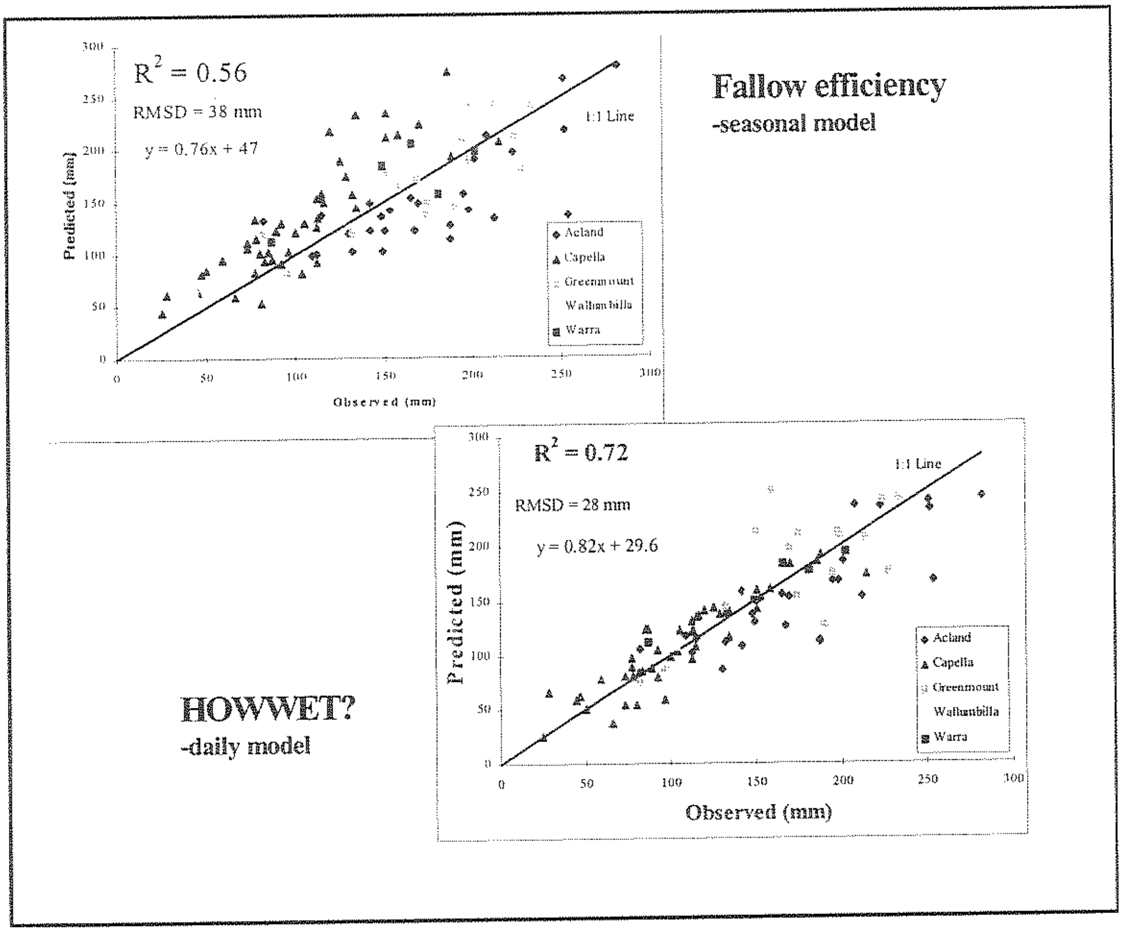

Figure 5. Comparison of predicted and observed plant available water using the 20% rule for fallow efficiency and HOWWET? for a range of fallows in southern Queensland and Northern Territory.

Like all decision support tools, HOWWET? is only suited to specific situations. While Howwet? can be used as a stand alone tool, we believe it should be introduced to potential users in a broader setting of workshops aimed at an improved understanding of soil processes. A comparison of soil water estimated from the fallow efficiency rule and HOWWET? is presented in Figure 5.

3.4 HOWOFTEN?

HOWOFTEN? is a simple program for examining historic rainfall records to determine the odds or chances of future rainfall events [Freebairn and Glanville, 1998]. The basic question Howoften? answers is: How often does x mm of rain fall in y days within a specified time period. The program provides a means to quickly explore rainfall records. The graphical output represents the variable nature of climate (Figure 6). Howoften? logically accompanies Howwet? when a decision has to be made based on current conditions *and* future expectations. For example, if I don't plant now because conditions are sub optimal, what are the chances of another opportunity?

3.5 Choices, Choices…

Choices Choices is a program for calculating the gross margin for crop rotations [Robinson and Glanville, 1999]. It was devised to assist farmers making decisions about crop sequences by organising yield, price and cost information as well as accounting for the temporal differences between crops. It does require the user to have a good understanding of yields and inputs for various crops and the impacts of successive crops on each other.

The program was originally developed in a spreadsheet, but was transferred to a stand-alone program as not all users had adequate spreadsheet skills. The program is less flexible than a spreadsheet but is easier to learn.

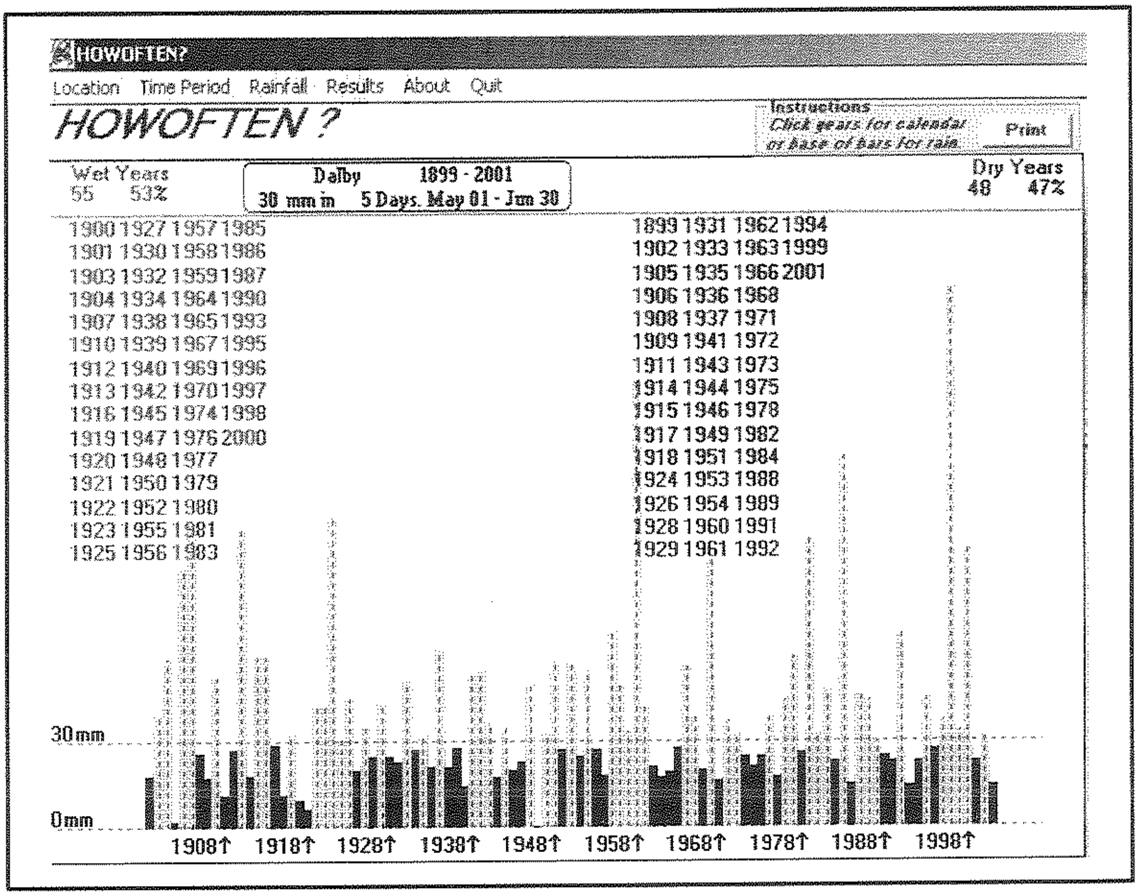

Figure 6. Output from HOWOFTEN? showing probability of receiving 30 mm in 5 days between 1st May and 30th June at Dalby. Display shows sequence of successes and failures, and how close each year is to the rule breakpoint. The user can examine detail of any years' rainfall by clicking on the year list.

3.5 PERFECT_ED

PERFECT_ED is an easy to use graphical user interface for PERFECT (Productivity, Erosion and Runoff Functions to Evaluate Conservation Techniques) [Littleboy et al., 1992], and is targeted at educational users and consultants. PERFECT is a daily time step model that simulates the dynamics of crops and soil in an agricultural system. It was developed to simulate the major effects of tillage management and environment on soil water, runoff, soil loss, drainage and yield, with an emphasis on soil management. Typical applications of PERFECT_ED include examination of erosion-productivity relationships and impacts of crop sequence, soil type and location on the components of the hydrologic cycle.

While there have been improvements in crop models since this model was developed (e.g. APSIM)[McCown et al., 1996], PERFECT is still an accurate and effective model that allows "non-modellers" to very quickly explore crop-soil interactions. When used in conjunction with Browser [McClymont et al., 2001], the dynamics and interactions within a crop or pasture system are easily visualised, leading to better understanding of the system.

4. EDUCATION AND FARM DECISION SUPPORT

The suitability of models for farm decisions applies in several respects to their suitability for education. All the models presented have been used for educational purposes. For instance, PERFECT_ED has been widely accepted as a useful interactive learning tool for environmental and agricultural studies at the tertiary level, while remaining a useful research tool.

In education, students have limited resources and time so inputs have to be simple to derive. Results must appear quickly and be reasonably accurate. Generally, a model output does not result in an irrevocable course of action. The program must be logical to use and require little training. Similarly, farm decisions supports must be quick and easy to use. Inputs must be well-known or easily obtained because farmers tend to intuitively integrate the complexities of their enterprises into a small numbers of applicable decisions. Complex models with multiple inputs appear irrelevant, and intimidate users who have not received advanced levels of training.

Personal preference is an inevitable part of farm decision-making. In some cases it is the most important factor. Simplified models such as HOWWET? that do not predict a final crop yield assist decision making by not presenting a *fait accompli* in which there is no room for personal bias or experience.

5. SIMPLIFYING MODELS: WHERE TO NEXT?

Decision-making is a way of producing a course of action from a set of alternatives based on the current status of our knowledge. Because decisions are easier to make if we have fewer alternatives, humans tend to condense the influencing factors down to the least number of possible combinations. This is partly the rationale for harnessing the complexity of large computer models in small, single purpose tools. In our experience, model users desire to take the next step and try to reduce the output of the models into manageable sets of numbers or rules of thumb. When this happens, the original model is deemed obsolete. In these cases, the conundrum is deciding whether the model is a failure or was in fact, too successful.

6. CONCLUSIONS

It appears that making models and modelling tools simpler can make them more usable, understandable and effective.

The cases presented here, where a model or models were reduced in complexity or specialised for a particular task, indicate that such approaches can be highly effective.

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