MANAGE RICE: DECISION SUPPORT FOR TACTICAL CROP MANAGEMENT

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Summary. maNage rice is a decision support system for topdressing nitrogen fertiliser on irrigated rice in the Riverina. The package estimates yield response to N in relation to the risk of cold damage. It consists of a Windows™-based Graphic User Interface connected to a simple model that simulates daily growth and yield in relation to radiation, temperature and N-status. It is designed for use by ricegrowers, and advisers and fertiliser dealers servicing the industry. The system allows for field-specific initialisation by users and provides options for topdressing, based on the user's acceptance of cold-damage risk and financial target for returns from applied N.

INTRODUCTION

The greatest environmental limitation to yield of rice in the Riverina is low temperature, both at the microspore stage when it leads to pollen sterility and throughout the vegetative and reproductive phases when cold reduces growth (5). The management factor often limiting yield is N supply. The reason that more N is not applied is because of increased cold sensitivity of high-N crops that leads to zero yield in extreme cases (5). The introduction of semi-dwarf varieties in the 1980s led to a rapid yield increases, mostly because semidwarfs resist lodging and hence tolerate higher levels of N. An additional benefit is that the microspores of semidwarfs develop when at a height of about 20cm, rather than the 30cm or more for tall varieties. It is therefore easier to increase the floodwater depth so as to insulate the developing microspores from cold air. This practice leads to large yield increases and is being rapidly adopted (9).

maNage rice is a PC-based system running in Windows™ that builds on the paper-based Ricecheck decision-support system (2). Ricecheck involves monitoring crop N-status at the panicle initiation stage through measurements of shoot density and the N-concentration of tissue using near infra-red spectroscopy. The N-recommendation of the Ricecheck system is based on correlations of measured N-status with yield response. maNage rice uses the same measurements of N-status in a simulation model to predict yield response in relation to these factors as well as to sowing date, water depth and temperature risk.

MODEL

The model simulates phasic development and growth in daily time steps (Table 1). It has evolved from predecessors (1, 10) characterised by the simplest structure consistent with accurate simulation and the only variables simulated are those that can be measured. Simplicity is justified by the dictum of Occam's razor, that the simplest possible explanation should be used to account for observations. There is also a need to restrict the number of parameter to the 5-6 that can be estimated using an optimiser.

Table 1. Summary of relationships in the simulation model.

Quantity or process simulated	Factors
Phasic development	Temperature, photoperiod, plant N-status
Growth	Intercepted radiation, temperature, plant N-status

Harvest index	Microspore temperature, plant N-status
N-uptake	Soil N-mineralisation, fertiliser, temperature
Microspore temperature	Water depth, screen temperature
Intercepted radiation	Global radiation, canopy cover
Canopy cover	Temperature, N-status, phasic development

An optimiser is a computer program linked to the model code so as to identify the parameter values that minimise the difference between observations and calculations. Optimisation has been used with engineering models and with physiological models of processes such as phasic development. Surprisingly, optimisation has been seldom applied to crop models since it was first used by Sands et al. (8).

An optimiser helps in the process of refining a model, for example when intercorrelation between parameters provides evidence of redundancy in model structure, and in helping to eliminate patterns where some sets of data are simulated worse than others. The process of optimisation has the advantage over the process of manual 'tuning' in that a model can be calibrated simultaneously on several attributes, such as growth and N-status (4). Most importantly, optimisation provides an objective way to evaluate a particular functional form within a simulation model because it provides parameters that give the best possible fit. If that fit is not satisfactory, the modeller can be certain that the function itself needs improving rather than remaining uncertain whether the function or the parameters are wrong. However goodness of fit is not the sole objective, and modellers themselves must ensure that functional relationships and parameter values are biologically reasonable.

Model fit

The data set for model calibration represents environments which straddle wide ranges of N-status, sowing dates, water depths and temperatures (Fig. 1). The calibrated model accurately interpolates within the range of experimental data and geographical region it is collected in and, because the functional relationships are based on biological principles, it is suitable for limited extrapolation outside the range of data. The process of optimisation ensures that data used for testing do not influence the process of calibration. During calibration the model fitted the yield data with a root mean square (RMS) error of 0.8 t/ha for yields from zero to 13 t/ha. In the experiments used for calibration, the l.s.d. was 1.0 t/ha. The model's RMS error was 0.9 t/ha when tested on yield data from independent experiments yielding from 6 to 13 t/ha.

Figure 1. Observed (points) and fitted (lines) rice yields in relation to applied N, water depth and sowing date.

GRAPHIC USER INTERFACE

The GUI is written in Visual Basic 3 and operates the model as a fortran dynamic link library. The same model from the optimisation routine is used for decision support (Fig. 2). The separation of GUI and model simplifies development of modules and partitioning of modelling tasks. This approach differs from the system of first developing a comprehensive model for research and then simplifying it to produce a summary model for decision support (7). There is no evidence that complex models are more accurate than simple models (3) nor that the process of developing a complex model adds insights for decision support.

Figure 2. Structure of the decision-support system, showing the same model used with the optimisation routine and as a dynamic link library with the graphic user interface.

Reporting risk

Simulation models are well suited to estimating weather-related risk and so have been widely used for strategic management (6). The financial risks of volatile prices and costs are of equal importance and can be addressed by delaying inputs for as long as possible. maNage rice uses the latest information on costs and prices, along with estimates of yield, to improve tactical management.

In reporting financial risk, maNage rice requires a *target return* for investment from the user, for example a farmer seeking a gross return of $2 for each $1 spent. The system calculates the probability of each input of exceeding that target (Fig. 3). The target approach is simpler and more easily communicated than the approach of devising long-term strategies based on cumulative frequency distributions of yield or income (6).

An important issue for computer-based decision support is whether a model should be run on-line or should store the results of previously run models in a database, as successfully applied in the wheatman system (11). In the case of maNage rice, the seven user inputs (region, dates of sowing and panicle initiation, water depth, tissue N%, shoot density, rice price and N cost) provide over 40 million combinations, clearly too many to simulate or store. maNage rice simulates yield for 9 rates of N over 40 years in about 15 seconds on a 486 PC.

Figure 3. Single screen output of maNage rice showing the mouse-controlled input variables and the graphical and numerical output of yield and economic returns.

CONCLUSIONS

Blanket recommendations seldom provide optimum strategies for individual fields so rules-of-thumb based on measurements such as tissue analysis have been developed for field-specific recommendations. Farmers are highly receptive to rules of thumb and computer-based systems are a natural progression which consider more factors, including current prices and costs.

In some cropping industries adoption has been limited because the ratio of grain price to input costs has been so high that farmers' have sought to ensure maximum yield by oversupplying inputs (A.B. Hearn, pers. comm.). This not the case with rice: for example, the ratio of N cost to rice price has fluctuated from 3.5:1 in 1993-94 when world rice price was high, to a possible 5.8:1 in 1995-96 following a rapid rise in N cost (Table 2). Simulating profit with these costs and prices for identical crops and seasons shows that the optimum N topdressing and the accompanying yield varies strongly. Providing timely information of this sort has the potential to increase farm profits. However, if widely adopted it could have the effect of increasing the variability of grain production and fertiliser usage.

Table 2. Rice yields simulated maNage rice for rice prices and N costs over three seasons, using the same starting values of crop N-status.

Season	Farm-gate rice price ($A/t)	Farm-gate N cost ($A/t)	Optimum N topdressing (kg N / ha)	Yield at optimum N (t/ha)
1994	250	670	170	9.1
1995	180	760	100	8.5

1996	180*	980	80	8.3

*forecast

About 20% of Australian farmers own personal computers but many are currently reluctant to use them for decision support, possibly because of unfamiliarity or reduced personal contact with advisers. Scientific institutions are also cautious about providing field-specific information because of the risks of litigation. Nevertheless, it is worthwhile to persevere with computer-based decision support systems because of their potential to provide information that is more comprehensive, objective and economical to deliver than through current advisory systems.

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