

DACS: A KNOWLEDGE-BASED DECISION SUPPORT SYSTEM FOR DRYLAND AGRICULTURE CROP SEQUENCING

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Abstract

Crop rotation is an important management strategy for dryland farming in Australia. A knowledge-based decision support system was developed using expert system techniques to select the best combination of crops over a period of time for the Wimmera region. This system consists of forty different sub-knowledge bases with several hundred production rules. The program combines heuristics with computer graphics and hypertext in the Microsoft Windows environment to design an optimum cropping plan on a paddock basis. As well as incorporating the knowledge and experience of experts, this program includes public knowledge about each of the crops and their management. This system can be used at the farm level and provides a consistent, satisfactory level of answers to people who need to choose their cropping options.

Key words: crop rotation, expert systems, knowledge-base

The allocation of a proper sequence of alternative enterprises to a paddock is one of the most critical decisions in dryland farming systems. The cropping options selected for a paddock are largely dependent on the farmers preference, soil type, rainfall, availability of machinery and labour, demand for commodities and the technology available. The carry-over effects, such as diseases and pests from this year's crop to the next have to be carefully evaluated when selecting crops for rotation. Since there are a number of alternatives, the decision to choose the best option would require the evaluation of all the cropping options. Due to the complexity and uncertainty of factors affecting crop production systems, decision-making for the selection of a suitable enterprise has become a difficult task.

Computer-assisted problem-solving techniques can be effectively used in the agricultural production sector. As a part of artificial intelligence technology, expert systems have been recognised as a powerful tool to store human knowledge in computers for the purpose of making expert's knowledge available to users. Expert systems are knowledge-processing computer programs intended to capture, preserve, use and extend the knowledge of experts (1). A knowledge-based decision support system (DSS) was designed, developed and validated using expert system technology for the selection of the best cropping plan for a three year period for the Wimmera region. An expert system shell was used to develop this system. The software developed for this project is named as DACS (Dryland Agriculture Crop Sequencing). The DACS system takes the farmer through a rational, step-by-step process to come up with a range of crop rotation plans best suited for each paddock.

Methodology

The area selected for this project, known as the Wimmera, is situated in the north-western region of Victoria. Traditionally, a pasture-fallow-wheat rotation was practised in this area, but increasingly crops are replacing the pasture phase and to a lesser extent fallow. The main enterprises in this region can be categorised into five major groups; cereals, grain legumes, oilseeds, pastures and fallow. The process of rotation and the selection of the best enterprise for a particular paddock does not have to be exact, or in other words, it is a fuzzy decision and there is no systematic way by which the most suitable crop rotation is found. Due to the complexity of dryland agricultural systems, the heuristic approach was found to be appropriate to design a suitable cropping plan (2).

A knowledge-based DSS which combines heuristics or rules of thumb, with computer graphics and hypertext was designed to solve the crop scheduling problem. The targeted end users for this system are extension officers and farmers and the system has been designed for operation by persons with no formal computer training. A feasibility study was conducted according to Walters and Nielsen (3) before starting

the development of this system. For the development of this system, experts were required from different disciplines of agricultural production systems such as soil, pests and diseases, agronomy and economics. A number of farmers from the Wimmera were selected and interviewed at the beginning of the project. The knowledge required to develop the system was acquired from experts at the Victorian College of Agriculture and Horticulture (VCAH) Longerenong and the Victorian Department of Agriculture in Horsham.

The domain of dryland agricultural systems was primarily decomposed into four sub-modules based on two long term average annual rainfall categories (less than 420 mm and more than 420 mm) and two soil types (self-mulching grey clay and red duplex soil) for the development of the system. The other important factor in selecting a crop rotation is the previous enterprise and a further decomposing of the problem domain was done based on the prior enterprise. Ten different enterprises have been considered for this system and each and every sub-module consists of ten separate independent knowledge bases, based on the prior crop. This system was designed to schedule a three year cropping plan on a per paddock basis. Over 1000 production rules were developed to build the entire knowledge base using the knowledge acquired from experts.

This system was developed using the LEVEL5 OBJECT expert system shell which follows the conventions of Microsoft Windows. The required input to the system is dependent on the scenarios used and the required basic inputs are expected rainfall values, size of the paddock, long-term average annual rainfall, soil type, prevailing pests and diseases, present nutrient and moisture status of the paddock, previous enterprise, information regarding applied herbicides, expected grain prices, expected yield and production costs. The user interface was designed so that the user can run the system with minimal computer knowledge. The user is guided through a series of questions about the inputs with pop-up windows and push buttons until the solution is reached. Forward, backward and mixed inferencing methods have been used for searching the knowledge base. At the end of the search procedure, the eight most suitable three year cropping plans, each with a projected gross margin and cost per hectare are displayed for the farmer to choose his best option. The system was validated using experts in the field and the system was able to give solutions with over 90% accuracy compared to expert's solutions.

Conclusions

The knowledge-based decision support system developed for north-western Victoria is capable of providing sufficient information to farmers in the selection of the best cropping sequence for their farms. This method offers the advantage of simplicity but does not guarantee a global optimal plan. The system can be installed in a basic personal computer and is easy to operate. It remains to be seen how well farmers will make use of such systems. Given the reduction in extension services from the public sector currently taking place, they may have little other choice.

References

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