

A KNOWLEDGE-BASED EXPERT SYSTEM FOR THE SUCCESSFUL PRODUCTION OF ALFALFA (*MEDICAGO SATIVA L.*)

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ABSTRACT: Expert systems, a form of artificial intelligence, may soon become an important management tool for agribusiness dealers, county agents, agricultural consultants, and farmers. An expert system can make the specialized knowledge of an expert available to crop managers and farmers when making critical management decisions. The expert system also informs the user as to how the recommendation or conclusion was reached on the screen or on the print-out. Purdue University agricultural scientists have recently developed a prototype alfalfa management expert system. This expert system models the procedures used by a forage expert in determining agro-economic recommendations for successful establishment and profitable production of alfalfa. With this expert system, information is readily available to alfalfa producers for making management decisions relative to liming, fertilization, drainage, weed control, longevity of stand, variety recommendations, and method and rate of seeding.

INTRODUCTION

Artificial intelligence emerged as a new field nearly four decades ago. However, progress was slow for several decades due to the early approach of utilizing sophisticated reasoning techniques without relying on a knowledge base (Giarratano and Riley, 1989). During the past decade, most of the artificial intelligence work shifted to knowledge-based expert systems. At present, the major limitation to the development of knowledge-based expert systems, especially in agriculture, is the lack of well-trained knowledge engineers.

An expert system is a written program, usually computerized, that imitates the decision-making process of a human expert. Expert systems offer many advantages to modern day high-technology agriculture. Some of these advantages are:

1. Permits mass production of expertise resulting in increased availability to agricultural producers.
2. Very fast response when expertise is needed.
3. Expertise is permanent — no illness, retirement, or death.
4. Is easily modified and/or updated.
5. User can observe the reasoning involved in reaching a conclusion.
6. Development of C Language Integrated Production System (CLIPS) will result in greatly reduced cost of expertise to user.

The objective of this study was to develop an alfalfa management expert system which would make the expertise of a forage expert readily available to agricultural advisors and farmers when critical management decisions must be made. This expert system was originally developed for selecting alfalfa varieties (Rhykerd, *et al.*, 1988, 1989, in press) and has been greatly expanded and updated to provide expertise for alfalfa establishment and production management decisions.

KNOWLEDGE ENGINEERING

The process of building a knowledge-based expert system is referred to as knowledge engineering. This process requires a domain expert, a knowledge engineer, and a development tool (expert system shell). The domain expert for developing this alfalfa management expert system for Indiana was C.L. Rhykerd. The knowledge engineers were R.L. Rhykerd, L.M. Rhykerd, and C.L. Rhykerd, Jr.. The development tool was PC Plus, an expert system shell from Texas Instruments, Inc. The expert system shell consists of an inference engine that determines the information that must be obtained (and in what order) from the knowledge base and from the user.

The first step in the knowledge engineering process is for the knowledge engineer to establish a dialogue with the domain expert and elicit the appropriate knowledge from the domain expert. The knowledge engineer must then code the knowledge explicitly into the knowledge base. The knowledge-based expert system is then evaluated by the domain expert. Any necessary modifications are given to the knowledge engineer for further refinement until the domain expert is satisfied with the performance of the expert system.

The advantage of a knowledge-based expert system, such as this alfalfa management expert system, over many conventional programming techniques is the ability to integrate subjective (heuristic), objective (factual), and incomplete or uncertain information that is used by a forage expert. The knowledge base in this alfalfa management expert system is in the form of facts and rules. This type of expert system reasons by moving from one rule to the next, gathering additional information about the user's particular situation as it proceeds through the rules. Eventually it gathers enough information about a given situation to make a specific recommendation.

The knowledge base for this alfalfa management expert system was developed for Indiana but could easily be modified for other States or regions. Alfalfa management considerations and the sequence in which they were built into the knowledge base are as follows:

1. Soil drainage. The first question posed to the user concerns the soil drainage classification, since this determines whether alfalfa can be successfully grown and whether a phytophthora resistant variety will be required.
2. Soil pH. Alfalfa is sensitive to soil pH. Therefore, the user is asked if the soil pH is 6.6 or above. The recommendation given is based on the response to the soil pH level of the field to be seeded to alfalfa.
3. Soil P test. This recommendation is based on soil P level supplied by user.
4. Soil K test. This recommendation is based on soil K level supplied by user.
5. Use of alfalfa crop. Soil improvement only or as a forage (hay or silage).
6. Weed control. Choice of companion crop or herbicides for weed control during establishment.
7. Expected longevity of stand. An indirect method of determining whether an anthracnose resistant variety is required. Bacterial wilt resistance is also a consideration.
8. Variety recommendation. A list of varieties is presented which possess the necessary attributes to assure success in establishment and production as desired by the user. Varieties can be listed by company, if desired. The knowledge base can be easily modified as varieties are released or discontinued.

9. Method and rate of seeding. Determined by input of user relative to seedbed preparation and method of seeding.

This alfalfa management system performs well and provides recommendations that are satisfactory to the domain expert. However, this expert system will not be made available to potential users in its present form due to high cost and legal restrictions. Consequently, the next step is to convert this alfalfa management expert system to CLIPS. CLIPS was just recently developed by the Artificial Intelligence Section at NASA/Lyndon B. Johnson Space Center. The CLIPS expert system tool was designed to greatly reduce the cost and legal restrictions associated with the development and use of expert systems. Robert T. Savely, Head of the Artificial Intelligence Section at Lyndon B. Johnson Space Center has recently stated (Giarratano and Riley, 1989): "Although CLIPS is but one of the first steps, it is an important step in the evolution of a technology that may be the most important advance in the history of mankind." The authors anticipate having this alfalfa management expert system converted to CLIPS within the next year.

CONCLUSION

The knowledge-based expert system, a form of artificial intelligence, will soon become an important management tool for agribusiness dealers, county agents, agricultural consultants, and farmers by making the specialized knowledge of an expert readily available to crop consultants and farmers. Purdue University agricultural scientists have recently developed a prototype alfalfa management expert system. The next step is to convert this expert system to CLIPS in order to reduce the cost and legal restrictions associated with making this alfalfa expert system available to users.

LITERATURE CITED

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