Proceedings of the Indiana Academy of Science
(1988) Volume 98 p. 499-501.

USING ARTIFICIAL INTELLIGENCE TO PROPERLY ESTABLISH ALFALFA

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INTRODUCTION

Artificial intelligence, as we know it today, had its beginning only about 3 decades ago. In the 1970s, artificial intelligence research began to focus on applying techniques to more specific subject areas and developing programs containing specific knowledge about a certain problem. This led to the development of expert systems (Stock, 1987; Jones, *et al.*, 1987). Agriculturally related expert systems are now being developed to help production managers make agriculture more efficient and profitable.

EXPERT SYSTEMS

An expert system is a written program, usually computerized, that emulates the decision-making process of a human expert. It allows a non-expert to reach the conclusion that would normally require consultation with an expert. An expert system tells the user how the recommendation or conclusion was reached and can further explain the question on the computer screen or on a print-out.

An expert system is developed for a specific, well-defined problem and uses an expert's knowledge and experiences to create a knowledge base. An advantage of expert systems over many conventional programming techniques is the ability to integrate subjective (heuristic), objective (factual), and incomplete or uncertain information that is used by the human expert.

In artificial intelligence parlance, the three major components in the development of an expert system are the domain expert, the knowledge engineer, and the development tool. The domain expert is the person who is the source of the expertise built into the knowledge base. The knowledge engineer extracts the knowledge from the human expert and translates it into a computer program. Lack of well-trained knowledge engineers has restricted the application of expert systems to agricultural problems. The development tool (shell) is simply a stripped-down expert system. Knowledge engineers build expert systems by adding a domain specific knowledge base to the shell.

DEVELOPING THE ALFALFA EXPERT SYSTEM

In this study, a rule-based expert system was developed which enables an alfalfa grower to produce higher yielding alfalfa. In developing this expert system, C.L. Rhykerd served as the domain expert and R.L. Rhykerd and C.L. Rhykerd, Jr. as knowledge engineers with assistance from D.D. Jones. In this study, PC Plus, an expert system shell from Texas Instruments, Inc., was used to develop the program by adding the knowledge base for maximizing alfalfa production.

The "knowledge engineering" process or stages involved in the development of an expert system are acquiring, formalizing, implementing, and verifying the knowledge required to develop the program. These stages have been discussed by numerous authors (Jones, *et al.*, 1987; Rhykerd, *et al.*, 1988; Stock, 1987).

The objective of this study was to develop an expert system that models the procedures used by a forage specialist in determining agronomic recommendations for profitable alfalfa production. This alfalfa expert system includes the following management decisions for successfully establishing a productive stand of alfalfa.

Further decisions on use of insecticides, harvest times, hay curing, or forage chopping, etc., remain to be added.

Soil pH. Generally, since alfalfa is very sensitive to soil acidity, the first management decision that must be made when considering the seeding of alfalfa, is lime requirement based on soil pH. Therefore, the first question posed by this expert system is, "Is the soil pH 6.6 or above?" If the response is "Yes", then the computer operator can proceed to the next management decision. If the response is "No", then the recommendation is to apply lime to raise the soil pH to 6.6.

Soil fertility. The second management decision built into the expert system concerns the P and K levels of the soil in the field to be seeded to alfalfa. Soil test results are required, to compare with those presented on the screen, indicating what the levels of P and K should be for a high soil test level.

Soil drainage. A well-drained soil is essential for the successful establishment and long-term maintenance of a productive stand of alfalfa. Therefore, the third management decision asks the computer operator whether the soil is well-drained, moderately well-drained, or poorly drained. The best alternative is well-drained, and the computer operator can proceed to the next decision. If the soil is moderately well-drained, then a phytophthora resistant variety is recommended, since phytophthora root rot is the primary reason for loss of alfalfa stands on wet soils. If soil drainage is categorized as poorly drained, the expert system will recommend that the farmer not seed alfalfa on that soil.

Chemical weed control. Alfalfa growers now have the option of applying herbicides when seeding alfalfa rather than relying on a small grain companion (nurse) crop to help control weeds. However, the decision as to which herbicide should be applied depends upon whether the farmer is seeding pure alfalfa or an alfalfa-grass mixture, since several of the herbicides kill grasses. Therefore, the first question posed by the expert system relative to chemical weed control is whether the seeding is pure alfalfa or an alfalfa-grass mixture.

Expected longevity of stand. Most alfalfa producers prefer to leave a stand for a period of 3 to 5 years, due to high establishment costs. However, it is not uncommon for a farmer to want only a two-year stand or possibly one season. Consequently, the expert system will ask the computer operator how long the stand is to be left. If the response is more than two years, the expert system will recommend an anthracnose resistant variety, because anthracnose is a major cause of loss of alfalfa stands in Indiana on well-drained soils after two years. Bacterial wilt can also cause loss of stand after two years, but all alfalfa varieties sold today in Indiana are resistant to bacterial wilt. Variety recommendations also can be made for a variety to be used for green manure during just one growing season.

Variety recommendation. An expert system which can make variety recommendations to alfalfa growers has been developed previously (Rhykerd, *et al.*, 1988). The alfalfa variety selection expert system was used as a basis for this alfalfa management expert system, because it became apparent that successful alfalfa production is possible only when all management practices are followed—not just variety recommendation. It is not possible to make alfalfa variety recommendations without knowing the management considerations, i.e., the expected longevity of stand, soil drainage, and use of the crop. A major advantage of an alfalfa variety selection expert system is that a knowledge engineer can easily update, add, or delete varieties.

Method and rate of seeding. The final management decision to be made in this expert system concerns method and rate of seeding. Seedbed preparation and method of seeding are key factors, determining rate of seeding alfalfa. Consequently, this expert system asks the computer operator how the seedbed is to be prepared and the type of seeder to be used in the seeding operation. Due to the very small size of an alfalfa seed, depth of seeding and firmness of seedbed can determine rate of seeding. Seeding rate can be considerably reduced by preparing a seedbed that is fine textured on the surface and using a seeder that places the seed very shallow but lightly covers the seed and firms the soil over the seed.

SUMMARY

The complexity of modern alfalfa production technology necessitates consultation with a forage expert in order to produce profitable yields of alfalfa. Recent advances in the application of artificial intelligence through the development of expert systems enable farmers to use a computer program to reach conclusions that normally require consultation with a forage expert. The objective of this research was to develop an expert system that models the procedures used by a forage specialist in determining agronomic recommendations for profitable alfalfa production. This expert system makes the advice of a forage expert readily available to alfalfa producers, when making management decisions relative to liming, fertilization, drainage, weed control, longevity of stand, variety recommendation, and method and rate of seeding. This expert system is designed to be user-friendly and permits the farmer to by-pass those management practices that do not apply or for which he has no data. (e.g., soil test results).

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