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Expert Systems for Decision Making in Agriculture Sector

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ABSTRACT

Knowledge based expert systems have been using in different fields of life like medicine, process controlling etc. Similarly, these systems are also being used in agriculture field in which different tasks from irrigation to harvesting are included. Expert System assists people in the making of environmentally sound and economically viable farm management decisions. Expert system can also be used as a training tool in agriculture sector because of its structured way of deriving knowledge and its explanation facility. There are some core areas of agriculture for which such type of systems have been developed and these areas include Pest management, Weed controlling, Fertilization, Farm planning, Agricultural engineering, Crop production, Natural resources conservation, Disorder management, Site evaluation, Variety selection, Marketing and finance management.

Key Words: Expert System; Knowledge Base; Agriculture

INTRODUCTION

Expert system (ES) is an intelligent software which works in one particular domain. It uses knowledge and inference capability to solve problems. Knowledge residing in knowledge base of expert system consists of domain facts and associated heuristics. This knowledge is collected from human experts who are not available every time. Moreover, one or two experts are not enough for some working areas just like agriculture where so many fields are part of one major field. That is why knowledge is gathered from more than one expert and accumulated to a software, which is called expert system. As expert system is based upon knowledge so this is also known as knowledge based system.

As expert systems have been using in different fields of life like medicine, process controlling etc. so agriculture field has also not been left affected by these knowledge based systems. These systems are being used by agricultural decision makers at different levels**:** "operation level and planning level. On the operation level, the extension workers in the village, district, and/or governorate can use the system to support him in making his decision in giving the appropriate advice to the growers. On the planning level, the decision makers can use the expert system to predict the needs of water, fertilizers, and pesticides" Reference; (Rafea, 1996).

Crop management is a difficult task as from irrigation to harvesting, farmers pass through many agricultural steps to grow and preserve the crops. In all agricultural areas, it is not possible for an individual or a group of people to take appropriate decisions without excessive knowledge, but expert system combines a lot of knowledge of so many experts at one point. "By helping people to consider all of the relevant information and by assimilating this information into an understandable format, ES assists people in the making of environmentally sound and economically viable farm management decisions" (Robinson, 1996).

Expert system can also be used as a training tool in agriculture sector because of two features. First, its knowledge derived from different sources is structured. "For example, by using an expert system for crop management, the crop consultant is forced to go through the entire reasoning process in a systematic manner ensuring consideration of all factors affecting the decision. Another feature of the KBS is the explanation facility which is inherently an educational tool. Explanation facilities provide reasoning which is important as a training tool for new personnel (Rafea, 1995). If Expert systems are made easy or user friendly, for example, the farmers interface can be designed in such a way that the communication between the expert system and the farmer will be in the farmers own native language then it would be easier to learn a lot from these systems.

The development and maintenance of serious ES, as with other software systems, is an expensive proposition because of the costs associated with employing specialized and often scarce human labour and expertise. For this reason, ES development projects must be selected carefully to ensure that the benefits of such development efforts are greater than the costs of producing such systems. Within the agricultural industry, where profit margins associated with primary production are typically low, the problem of cost recovery for ES development can be further exacerbated" (Robinson, 1996)

Use of expert systems in core areas of agriculture. Some times only one expert system covers a lot of agricultural fields so it can be used as a good crop management advisory system. NEPER is one of those systems, which was implemented using a tool developed at Michigan State University on top of the object-oriented language Small Talk. The expert system (NEPER) included two subsystems: the strategic subsystem, and the tactical subsystem. The strategic subsystem consists of six modules namely: variety selection, pre-cultivation, pest control, tillage, planting, irrigation and fertilization, and harvest. The tactical subsystem consists of two modules namely: weed identification and control, and diagnosis and treatment (Refea, 1998). Usually, NEPER like huge expert systems which cover agriculture in broader sense are very few in numbers, but many other knowledge based expert systems have been developed for one or two related areas of agriculture. Some of them are as follows:

Pest management systems. These systems are consulted for identifying the risk of pests and the use of insecticides or pesticides. Furthermore, these systems are also helpful for the proper use of spray in proper season along with the right use of equipment related to these activities.

MAIZE/NAPRA expert system. The MAIZE expert system was developed by Penn State University to help extension agents and agribusiness personnel identify pest management strategies in field corn for their clientele. NAPRA (National Pesticide Risk Assessment) was developed by the Soil Conservation Service (now the Natural Resource Conservation Service) to assess the relative risk of pesticides contaminating the ground or surface water. Then a joint MAIZE/NAPRA program was designed by linking the output of the NAPRA program with the MAIZE expert system (MC McClure, 1996).

Six-vegetable expert system (VEGES). VEGES was developed with the aim of providing diagnosis and treatment for the diseases and disorders of the species most commonly cultivated under cover in the Mediterranean region: pepper, lettuce, cucumber, bean, tomato and aubergine. Although the VEGES has been designed for use by greenhouse growers of the Mediterranean region, it could equally be adopted by growers in other parts of the world, where similar, simple greenhouses are used for vegetable crops (Yialouris, 1997).

Sprayer nozzle selection and sizing–expert system. This system was designed to assist in the selection and sizing of spray nozzles, covering 275 nozzles and is rated based on five factors. The overall ranking of the nozzles selected is based on nozzle type, operating pressure, nozzle spacing, boom height and droplet size. A nozzle interchange database is available for five nozzle manufacturers (Grisso, 1994).

Weed control systems. Weed is known as an unwanted plant, characterized by rapid growth. It typically replaces other, more desirable plants. Usually mechanical or cultural methods are used but nowadays along with herbicides or chemicals, different biological methods are also being used to control the weeds and such type of systems give suggestions related to all of these methods.

Semagi. An interactive microcomputer program named SEMAGI has been developed for sunflower to determine the appropriate selection of herbicides. It combines relational databases on herbicides, weeds and their interaction. The expert system processes and selects the herbicide(s) under the constraints of herbicide efficacy data and of a weed-crop competition model. In addition, SEMAGI provides an economic study of any herbicide treatment selected or introduced by the user, based on herbicide treatment cost, expected yield increase from the weed control treatment and sunflower selling price (Castro.-Tendero, 1995).

Fertilization management systems. Fertility of a soil is the quality that enables it to provide nutrients, in adequate amounts and in proper balance, for the growth of specified plants, when other growth factors such as light, moisture, temperature, and the physical condition of the soil are favorable.

Farm nutrient management expert system. A computer program was developed to assist farmers in developing customized farm nutrient management plans that reduce crop production costs and environmental risk. The program uses detailed farm information to determine the field by field allocation of manure and to balance this with commercial fertilizer additions (Robinson, 1996).

Farm planning systems. Overall farm planning includes crop storage, protection of farm, cattle management and financial strategies, so all of these activities can be managed at a time in a proper manner by such type of systems.

Sepa. This program has two operational modes: representation and simulation. The first mode permits us to maintain and update two data files: one for current product value data, production factors, market information, methods for crop/forage seeding and its protection; another file for specific ranch data such as extension and division, semi-yearly crop rotation plan and cattle grouping. Simulation is the second mode, permitting us to achieve a one year's production plan and forage balance in order to know the activity schedule, grazing plan and cash flow. This information is used to obtain the gross margin of each activity and the total margin. SEPA was developed in PDC Prolog programming language and was based on the 'gross margin as a decision tool' concept, developed by AACREA Institution (Delgado, 1996).

Agricultural engineering systems. Such types of expert systems are designed to give engineering solutions such as development of artificial environmental plant chambers etc. Similarly, these systems are also helpful to learn usage of any machine for agricultural purposes.

Expert system to diagnose chilling injury symptoms on fresh fruits and vegetables. This system was designed to diagnose chilling injury (exposure to low, nonfreezing temperatures) symptoms, which are not same for all

commodities and can be influenced by environmental factors. So we can prevent the market life of certain commodities to be shortened by chilling injury (Bergsma, 1997).

Expert system for soil erosion control planning. The main purpose of this system was to control soil erosion in agricultural area of Prince Edward Island by recommending appropriate engineering solution. This system was developed at the Technical University of Nova Scotia as a doctoral dissertation using the rule-based PC plus Expert System Shell by Texas Instruments (Arbour, 1993).

Crop production systems. To improve the overall crop yield, such type of systems are made to provide better decisions related to frost protection strategies**,** soil temperatures for planting, harvest weather guidance, crop storage environment ((Landry, 1994) and proper crop rotation etc.

Field master. The Work Efficiency Institute in Finland has developed this knowledge-based computer program for planning plant production. It helps the farmer to select the appropriate plant and variety for a certain field and to select the appropriate fertilizers and limes. The program guides the user in the direction of sound farming practice by favoring proper crop rotation and by calculating the fertilizer application levels for the different parts of the field according the actual soil properties. This system was programmed with Nexpert Object, a rule-and-object based expert system shell running in the PC-environment (Palonen, 1994)

Natural resources conservation systems. Such types of expert systems are used to conserve the natural resources. There are two problems facing decision makers to conserve water resources namely: efficient utilization of water resources, and the pollution resulting from the usage of chemical fertilizers and pesticides. Regarding soil conservation, there are two main problems namely: the urban expansion, and the soil degradation resulting from excessive use of fertilizers and other bad agricultural practices (Rafea, A. 1995)

Fertigation expert system. This ES is part of CUPTEX (cucumber production management under plastic tunnel expert system), which was developed by Central Lab. for Agricultural Expert System (CLAES) within the Ministry of Agriculture and Land Reclamation, Egypt. CUPTEX was developed using a methodology based on KADS and composed of three expert systems: Fertigation, Plant Care, and Disorder Remediation. "The main function of Fertigation expert system is to give the user a recommendation about the quantity of different fertilizers and the optimum irrigation water quantity that fits his/her situation at any cultivation stage. This model takes number of inputs representing the current situation of the environment including, plant age, soil type, water salinity, climate, and some factors related to the plantation itself such as the drainage quality, the soil sterilization, the sequence of grown cucumber in the same tunnel, the type of fertilizers to be applied, and others factors related to the fertilizers to be used and the expected yield (Rafea, A. 1995). Similarly, soil conservation expert systems have also been made such as:

Soil Crop. An expert system for Soil Conservation Crop Productivity Relationships

ASK. An Agronomic Soil Conservation Knowledge Base (Bentham, 1998)

Disorder management systems. These systems are helpful for disorder management, for example, disorder in nutrients or livestock etc.

Disorder remediation expert system. This system is also the part of CUPTEX as mentioned before. The main function of this expert system is to generate a prescription to protect a certain disorder or a set of disorders. In case that the user suspects the cause of disorder(s), he/she can provide the system with his/her suspicion, and the system confirms or rejects this suspicion. If the user has no suspicion, he/she can provide the system with the symptoms of the disorders, and the system identifies the cause(s) of the disorder(s) (Rafea, 1995).

Site evaluation systems. Systems in this category are used to determine that whether a site is suitable for cultivation or not. If not then which type of actions should be taken before cultivation.

Land evaluation using an intelligent geographical information system (LEIGIS). In this system, expert systems and geographical information systems technologies are combined. LEIGIS has been implemented using the expert system shell "CLIPS". The model used is based on the "Food and Agriculture Organization of the United Nations" (FAO) land classification for crops, and data which describe an agricultural area in terms of soil mechanics and environment. This expert system has been designed to help with the evaluation of land and to allow alteration in its rules based on different performance observed in local areas. The GIS functions help in managing the spatial data and visualizing the results. The software developed allows the evaluation and presentation of any equivalent spatial dataset and does not require special computer skills (Kalogiroi, 2002)

Variety selection systems. These systems give suggestions for better variety selection to improve over all crop production according to the soil type, the weather, resistance to certain diseases and the user requirements.

Wheatwiz. The expert system software WHEATWIZ was developed in 1987 as an effective tool to assist Kansas farmers, extension workers, and agri-business personnel in variety selection for hard red winter wheat (Zhang, 1992)

Marketing and financial advisory systems. Just like other organizations, farms also need better management in terms of finance and marketing. Farmers should be able to make better marketing strategies and manage financial data. These systems help as financial and marketing advisors.

GMA (Grain Marketing Advisor). This ES was developed at Purdue University in Indiana and it helps farmers select and analyze marketing alternatives for their

grain. These alternatives include the cash market, futures markets, forward contracts and basis contracts. This system was developed using Personal Consultant (Uhrig, 1989)

A financial analysis review expert system (FinARS). This system can be used as a diagnostic tool for the farm's financial situation. FinARS consists of four basic components, viz. profitability, liquidity, solvency and integrative (Bryant, 1999)

CONCLUSIONS

As an economical aspect, expert systems can clearly affect over all agricultural production. Similarly, we can preserve our natural resources instead of being polluted because of excessive and wrong usage of chemicals and fertilizers. Moreover, better training of extension workers through these systems can also be beneficial. These systems are completely computer based but the people living in third world counties are not fully computer literate. Hence the use of expert systems in these countries is still a dream. That is why there is also a need to work in this regard.

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