SEMINAR REPORT

Expert systems for demand driven extension

By

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CERTIFICATE

This is to certify that the seminar report entitled **"Expert systems for demand driven extension"** has been solely prepared by **Malliboina Mahesh Yadav (2018-11-127)**, under my guidance and has not been copied from seminar reports of any seniors, juniors or fellow students.

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DECLARATION

I, Malliboina Mahesh Yadav (2018-11-127) declare that the seminar entitled **"Expert systems for demand driven extension"** has been prepared by me, after going through various references cited at the end and has not been copied from any of my fellow students.

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1. Introduction

Agricultural production has evolved into a complex business which requires collection of knowledge from different sources. In order to remain competitive, the modern farmer often relies on agricultural specialists and advisors for decision making, whose assistance is not always available when the farmer needs it. To meet this challenge, expert systems were developed and identified as a powerful tool with extensive potential in agriculture, since it integrates information from a number of experts. Text, image, video and audio are the forms of media on which information can be found, and the role of information technology is to devise tools to store and retrieve this information. Several systems have been designed for crop production, diagnosis, and crop management (Joy and Sreekumar, 2014).

2. Definition of an expert system

Expert system is an intelligent computer programme that uses knowledge and inference procedures to solve problems that are difficult enough to require human expertise for their solution (Durkin, 1994). Agricultural expert systems are tools for agricultural management since they can provide site specific, integrated and interpreted advice that farmers and consultants need to more efficiently manage agricultural concerns (Rajotte *et al*., 2005). An expert system also called a knowledge based system is a computer program designed to simulate the problem-solving behavior of an expert in a narrow domain or discipline. In agriculture, expert systems unite the accumulated expertise of individual disciplines, e.g., plant pathology, entomology, horticulture and agricultural meteorology, into a framework that best addresses the specific, on-site needs of farmers. Expert systems combine the experimental and experiential knowledge with the intuitive reasoning skills of a multitude of specialists to aid farmers in making the best decisions for their crops (Prasad and Babu, 2006).

3. History of expert systems

Development of expert systems had stared since 1960s. Dendral was the early expert system developed in 1965 which was a chemical analysis expert system (Divya and Sreekumar, 2014). MYCIN was another expert system developed in 1973, which was used to identify bacteria causing infectious diseases (Divya and Sreekumar, 2014).

3.1 History of agricultural expert systems developed outside India

POMME (Roach *et al.,* 1985) was an expert system for Apple Pest Orchard Management. It was developed in Virginia to help in managing diseases and insect-pests on apples. This system was designed to provide growers with knowledge about fungicides, insecticides, freeze, frost and drought damage, non-chemical care options as well as information from a disease model (Boniface and Husain, 2006).

COMAX (Lemon, 1986) was an expert system, which provide information on integrated crop management in cotton. It was designed for use by farmers, farm managers, and county and oil conservation agents. The system used a combination of expert-derived rules and result generated by the cotton - crop simulation model GOSSYM. This was the first integration of an expert system with simulation model for daily use in farm management (Mishra *et al.,* 2014).

CALEX (Plant, 1989) was an expert system for the diagnosis of peach and nectarine disorders. The system could diagnose 120 disorders of peaches in California, including insects, diseases, and cultural problems. The user can begin a session by identifying a area on the plant where the problem occurs.

PREDICT was an expert system for diagnosing pest damage of red pine stands in Wisconsin, runs on IBM or compatible microcomputers and was designed useful for field foresters with no advanced training in forest pathology or entomology. PREDICT could recognize 28 damaging agents including species of mammals, insects, and pathogens, as well as two types of abiotic damage. Two separate development tools (EXSYS and INSIGHT 2 +) were used.

COUNSELLOR was developed in England by ICI Agrochemicals to manage insect and diseases on wheat. It was developed on a DOS computer using the expert system shell Savoir. This shell is unique in that it uses evidence nets to predict risk of disease and to optimize treatment recommendations. COUNSELLOR displays a cost benefit analysis for the treatment recommendation.

GRAPE was an expert system for viticulture in Pennsylvania. This expert system was developed at Pennsylvania State University in association with Texas A&M University to address the advisory needs of grape growers. This system provides grape growers with recommendations regarding pest management (insect, disease and weed control), fertilization, pruning and site selection.

3.2. History of agricultural expert system in India

Rice-Crop Doctor (1994) - Developed by the National Institute of Agricultural Extension Management (MANAGE) was the pioneer expert system in agriculture (Prasad and Babu, 2006), it diagnose pests and diseases for rice crop and suggest curative measures.

Agricultural expert systems on grape and mushroom (2000) - The first software for use by the grape cultivators was developed by the Indian Institute of Horticultural Research Institute, Bangalore. The spontaneous response from the users made them to undertake similar software for providing guidance to mushroom cultivators, which became extremely popular and a large number of growers use it regularly for getting solutions to their problems. (Helen, 2008)

Farm Advisory System - Punjab Agricultural University, Ludhiana, has developed the Farm Advisory System to support agribusiness management. The conversation between the system and the user is arranged in such a way that the system asks all the questions from user one by one which it needs to give recommendations on the topic of farm Management.

SUGAREX - Developed by Sugarcane Breading Institute, Coimbatore for sugar cultivation.

ESMMDM - The Expert System for Management of Malformation Disease of Mango, is a crop and disease specific expert system for crop protection. It is a user friendly and interactive system. This enables the user to reach the correct inference about a particular case.

Pesticide advisor - It is developed as crop nonspecific expert system for protection. It is user friendly and simple tool to provide advices about preventive and curative pesticides to manage almost all important crops cultivate in India. It is beneficial for farmers as well as the research scientists. It deals with 723 pests that affect 94 crops using 198 pesticides treatment policies.

3.3. History of agricultural expert system developed in Kerala

AGREX - Center for Informatics Research and Advancement, Kerala in association with Kerala Agricultural University has prepared an expert system called AGREX to help the agricultural field personnel give timely and correct advice to the farmers. This expert system find extensive use in the areas of fertilizer application, crop protection, irrigation scheduling, and diagnosis of diseases in post-harvest technology of fruits and vegetables.

DIAGNOS-4 - Kerala Agricultural University developed DIAGNOS-4 for pests and diseases identification and IPM recommendations of nine major crops of Kerala. Which has drawn tremendous attraction from extension personnel. The user when selects a complaint, a list of symptoms will appear on the screen (Helen, 2008).

CROP - 9 - DSS - is developed by Kerala Agricultural University for Cultivation practices of nine major crops of Kerala (Boniface and Husain, 2006).

4. Need of Expert Systems in Agriculture

The need of expert systems for technical information transfer in agriculture can be identified by recognizing the problems in using the traditional system for technical information transfer and by proving that expert systems can help to overcome the problems addressed and are feasible to be developed (Das and Nayak, 2013; Mishra *et al*., 2014).

Static Information: Examining the information stored and available in the agriculture domain revealed that this information is static and may not respond to the growers need. All extension documentations give general recommendations because there are many factors if taken into consideration, so many different recommendations should be included in the document.

Specialities Integration: Most of the extension documents handle problems related to certain specialty: plant pathology, entomology, nutrition, or any other specialty. In real situations the problem may be due to more than one cause and may need the integration of the knowledge behind the information included in the different extension documents and books.

Combination of more than one information source: Images may need sometimes an expert to combine other factors to reach an accurate diagnosis, and even if a diagnosis is reached, the treatment of the diagnosed disorder should be provided through extension document.

Updating: Changes in chemicals, their doses, and their effect on the environment should be considered. Updating this information in documents and distribute them takes long time. The same arguments can be made for audio tapes that are another form of extension documents but in voice instead of written words. Video tapes are more stable than other media as the information provided through the tape describes usually well-established agricultural operations. However, if the tape includes information as what is commonly included in documents and audio tapes, this information should be updated.

Information unavailability: Information may not be available in any form of media. It is only available from human experts, extensionists, and/or experienced growers. In addition, the information transfer from specialists & scientists to extensionists and farmers represents a bottle neck for the development of agriculture on the national level. The current era is witnessing a vast development in all fields of agriculture. Therefore there is a need to transfer the information of experts in certain domain to the general public of farmers, especially that the number of experts in new technologies is lesser than their demand.

5. Components of expert system

There are four essential component of a full-fledged expert system such as Knowledge acquisition module, Knowledge base, Inference engine and Explanatory interface (Bahal *et al*., 2006).

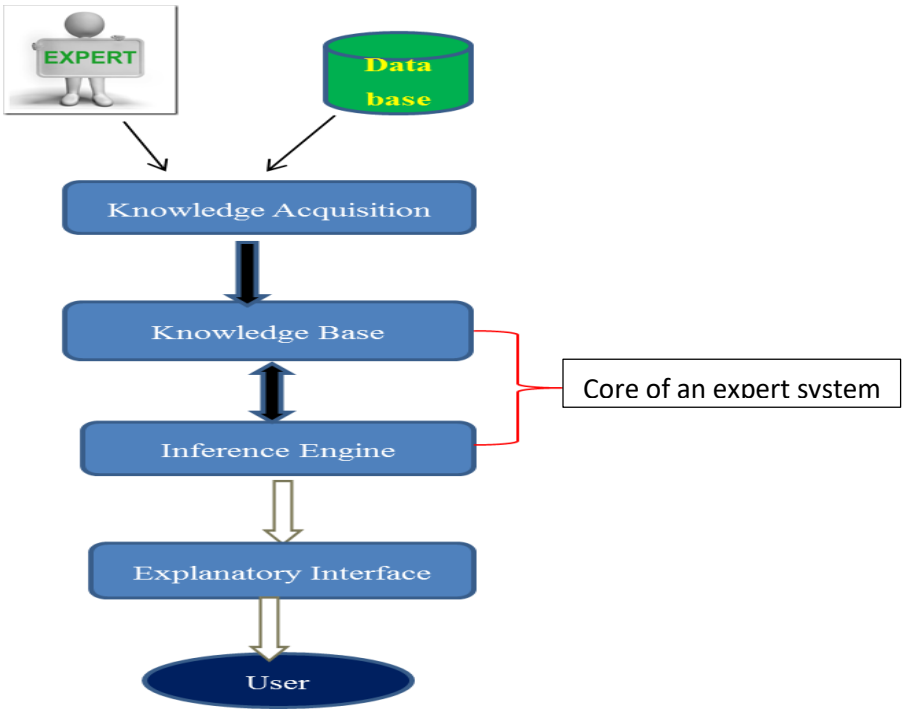

Fig.1. Components of expert system

5.1. The Knowledge acquisition module: Knowledge in terms of a computer program is information that makes computer to behave intelligently. It may be in the form of facts, beliefs, and heuristic rules. An integrated collection of facts and relationships that when exercised, produces competent performance. The quantity and quality of knowledge possessed by a person or a computer can be judged by the variety of situations in which the person or program can obtain successful results.

Essentially, the knowledge acquisition is the technique by which a knowledge engineer obtains information from experts, textbooks, and other authentic sources for ultimate translation into a machine language and knowledge base. The person undertaking the knowledge acquisition must convert the acquired knowledge into a form that a computer program can use. One of the possible ways of representing knowledge is to encode it in the form of rules. Knowledge acquisition module in expert system of extension accepts knowledge from the panel of experts identified for the each crop of the project. Apart from the heuristic knowledge of the experts, it also stores the facts from the textbooks, technical & extension bulletins and finding of the research projects (Jamsandekar and More, 2013).

5.2. The Knowledge base: The knowledge base is the core component of any expert system since it contains the knowledge acquired from an expert in the field. Typically, a knowledge engineer is responsible for working with an expert to build the knowledge base for the system. The knowledge engineer must perform a detailed analysis of the inference process and develop the prototype knowledge base. The tasks involved in developing the knowledge base include knowledge acquisition, knowledge representation, knowledge programming, and knowledge refinement (Katkamwar, *et al*., 2013).

5.3. The Inference engine: The heart of an expert system is the inference engine or reasoning engine. The reasoning engine processes the input statements of the problem statement document. This input is usually present the reasoning engine in an in-memory tree structure, having first been processed by a lexical analyzer and parser. The chief task of the reasoning engine is to take a problem statement, for instance a goal statement, and to match the set of attributes of the goal against a set of attributes in the rule base in a rule consequent table. The reasoning engine uses the results of this match to start retrieving the corresponding rule antecedents. There may be multiple parallel antecedents for a given goal, and/or there may be multiple antecedents that will form a chain of state description records as they are retrieved. The reasoning engine works together with the code generator to the effect that all necessary source code fragments are retrieved and combined to form a larger target program fragment, which is written to an output program file. An important part of this process is that of performing substitutions - the generator will in most cases be able to take values directly from the input specification statements and use them in a function that substitutes actual values for attribute value placeholders (Bahal *et al*., 2006).

5.4. Explanatory interface: As a web-based application, the Expert System of Extension (ESE) user interface is designed using the hypertext markup language (HTML), Cascaded Style Sheet (CSS), Java Script (JS) and Java Server Pages (JSP) to allow the user to access the system with a web browser such as Microsoft Internet Explorer or Netscape Communicator, *etc*. The interface contains two main modules. Firstly, the expert system module that helps the user to decide a particular crop/cropping system on the basis of available resources with the farmer and second, the information system about the chosen crops. The information system module provides step-by-step implementation details and is closely integrated with the expert system module. The system also acts as an extension agent in dissemination of recent technologies and advancements

in the field of agriculture with a generic search capability. The system also contains images, sound and movie clips to effectively disseminate the technology (Jamsandekar and More, 2013).

6. Categories of expert system

Expert systems may be applied to any situation that normally requires human expertise. Expert system applications divided into different functional categories (Waterman, 1985).

Diagnosis - inferring system malfunctions from observations for medical, agriculture and electric fields.

Repair - executing plans to administer prescribed remedies for automobiles / computers.

Interpretation – inferring situation descriptions from sensor data for speech and image analysis and surveillance.

Forecasting - Inferring likely consequences of given situations

Design and planning - configuring objects under consequences and designing actions

Monitoring - Comparing observations to expected outcomes – for power plant and fiscal management.

Control - Interpreting, predicting, repairing, and monitoring system behaviours.

Debugging - Prescribing remedies for malfunctions for computer software.

Selection - Modeling the interaction between system components.

7. Methodologies used for Development of Expert Systems

Rule based system:

The knowledge base is a collection of rules or other information provided by the human expert. These rules consist of a condition followed by an action (IF condition...THEN action). The rule can then be used to perform operations on data given as input in order to reach appropriate conclusion. It is used for prevention, diagnosis and control of diseases, agricultural advisor and production planning.

Case based reasoning:

In this approach, knowledge base contains the solutions that have been already achieved uses to get a solution to the new problem. Here the descriptions of past experience of human experts, represented as cases, are stored in a database for later retrieval when the user encounters a new case with similar parameters.

Knowledge based system:

The concept of Knowledge Based System (KBS) is rooted in the field of artificial intelligence. This system tries to initiate and adapt human knowledge in a computer program. The basic components of KBS are knowledge base, inference engine, tool for knowledge engineering and specific user interface. It is used for agricultural management, plant process control and environmental protection.

Neural networks:

The concept Artificial Neural Network (ANN) is used to implement software simulations for the massively parallel processes that involve processing elements interconnected in network architecture. It can be used to convert data signals to special format. It is used for decision making and knowledge learning.

Fuzzy logic:

Fuzzy expert systems are developed using the method of fuzzy logic, which deals with uncertainty. This technique uses the theory of fuzzy sets, simulates the normal human reasoning process by allowing the computer to behave less precisely and logically than conventional computers. It is used for uncertainty reasoning and disease diagnosis.

Object oriented methodology:

This method combines one object with specific procedure that operates on data. Instead of passing data to procedures, programs send a message for an object to perform a procedure that is already embedded in it. It is mainly used for disease diagnosis

8. Applications of expert systems

Expert systems are applied in different fields like medicine, agriculture, education, mathematics, meteorology, information management, computer systems, electronics, law, engineering, chemistry, physics (Waterman, 1985).

In agriculture, expert systems is applied in crop selection, soil management, nutrient management, plant disease and pest management, weed management and estimation of crop yield (Rafea and Mahmoud, 2001).

9. Expert systems in agriculture

9.1. Agricultural expert systems developed in India

Some of the agricultural expert systems developed in India, which are being used at present are RubSIS, Rubber clinic, AgriDaksh, EXOWHEM, Paddy expert system, Coconut expert system, Sugarcane expert system, Banana expert system, Finger millet expert system *etc.*

AgriDaksh: Developed by IASRI, New Delhi. A tool for building online expert system which enables domain experts to build online expert system in their crops with minimal intervention of knowledge engineers and programmers. This is a generic system for all crops with ability to create knowledge models for new crops. It has diseases diagnosis, insect's identification and variety selection. It has comprehensive plant protection module that provide information on diseases, insects, weeds, nematodes and physiological disorders.

EXOWHEM: The system is designed as web-based application by IASRI, New Delhi for wheat growing farmers of India. It provides complete information about the wheat crop management in the country. It advises wheat varieties on the basis of area, cultural and climatic conditions and other characteristics of farmer's interest. It also suggests the appropriate cultural practices like field preparation, fertilizer application, schedule of irrigation and guides them in protecting the crop from insects, diseases, weeds. Provides solution to the problems faced by the farmers through online queries.

Plate1. EXOWHEM

Rubber Clinic: Developed by Rubber Research Institute of India. Diseases and pests of rubber lead to significant crop/tree loss. Early diagnosis and timely adoption of control measures can avoid such losses. This web-based diagnostic system tries to assist the farmers in analyzing their field observations systematically to arrive at the correct diagnosis of the disease/pest problem and lead them to the recommendations on the management of these problems. This system also provides facility for direct interaction of the farmer with the experts on the internet. The observations/photographs on symptoms that are difficult to be diagnosed can be posted on the site to get prompt diagnostic assistance and recommendations.

Plate2. Rubber Clinic

RubSIS: Rubber Soil Information System. It is a collaborative project of Rubber Research Institute of India, Rubber Board, Ministry of Commerce & Industry, Govt. of India and Indian Institute of Information Technology & Management - Kerala.

Rubber growing area (three years and older) in each panchayat was mapped with medium resolution satellite images of scale 1:50000 and one composite soil sample (0-30 cm) was collected from each 50 ha rubber area. Soil samples were also collected using core samplers to determine the gravel content. Location coordinates of sites of soil samples were recorded by GPS. 11000 soil samples were collected from rubber growing regions of South India.

Plate3. RubSIS

Rice Knowledge Bank (RKB): To bridge the gap between research and practice in rice production, the International Rice Research Institute (IRRI) developed the Rice Knowledge Bank (RKB). It is a digital extension service that provides practical knowledge solutions, specialized for small-scale farmers in developing countries.

RKB showcases rice production techniques, agricultural technologies, and best farming practices based on IRRI's pool of knowledge from research findings, learning and media resources, and in-country projects. To facilitate easy access to information, RKB highlights the Step-by-step Production Stages from pre-planting to postproduction management, Decision Tools, and Agronomy Guides to help people make informed farming decisions.

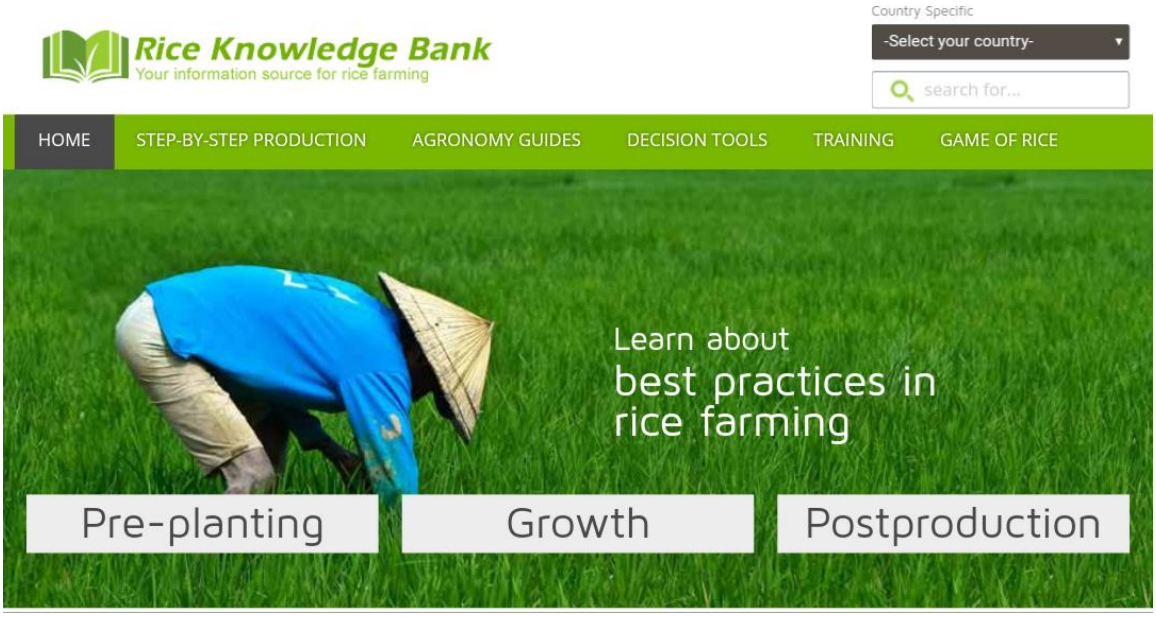

Plate4. Rice Knowledge Bank

9.2. Agricultural expert systems developed in Kerala

Some of the agricultural expert systems developed from Kerala which are being used at present are e-Crop doctor, Fertulator, Seed rate and spacing, Agri Almanac and e-DID developed by Kerala Agricultural University, Thrissur. Cassava Expert System, Oushadam, Cassava variety identifier, Tuber crops online marketing, Cassava protector and Cassava Soil nutrient management by Central Tuber Crops Research Institute, Thiruvananthapuram.

e-Crop doctor: It is a plant protection advisor for the crops of Kerala. It is developed for the farmers and agri-stakeholders in Kerala. It gives the chemical recommendations to control pests and diseases.

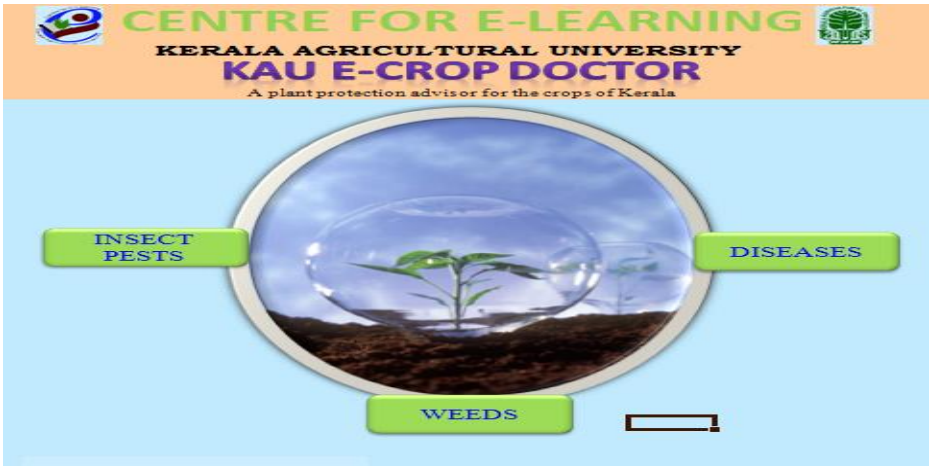

Plate5. e-Crop doctor

e-DID: Electronic Device for Drip Irrigation Design. It works based on the user's capability and database availability. It is mainly designed for ten major crops of Kerala.

Plate6. e-DID

Fertulator: It is an application software developed for the farmers and other agri-stakeholders in Kerala, for easy calculation of the fertilizers. It gives the quantity of N, P and K supplied by different complex fertilizers by entering its weight in kg.

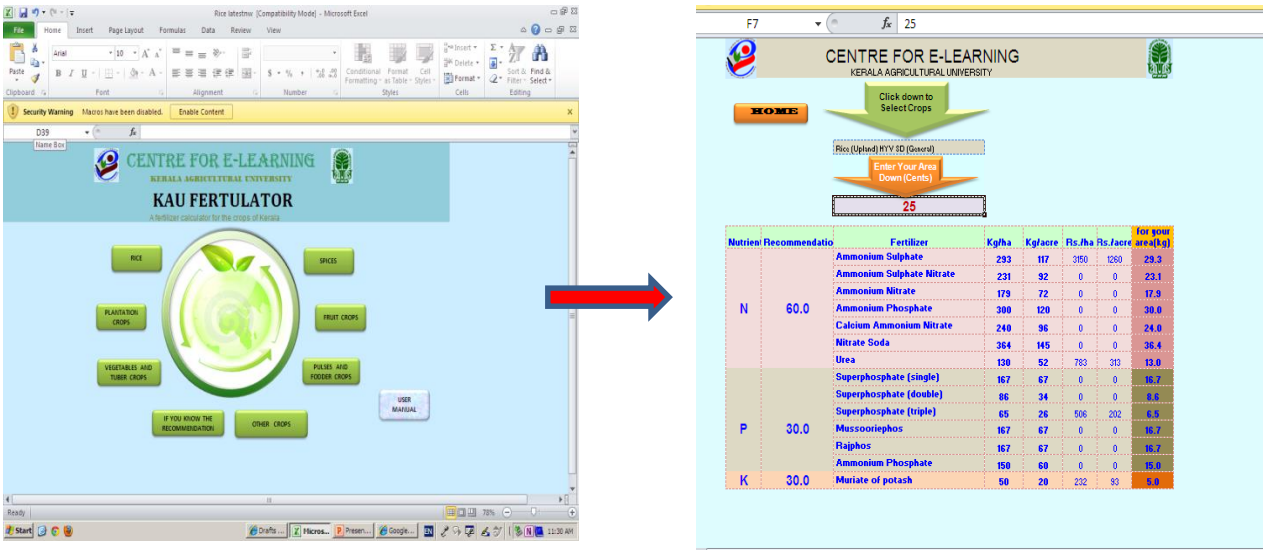

Plate7. Fertulator

Seed rate and spacing: It is an application software developed for the farmers and other agri-stakeholders in Kerala, for easy determination of the spacing and seed rate of various crops grown in the field.

Plate8. Seed rate and spacing

Cassava expert system: Developed by Central Tuber Crops Research Institute, Thiruvananthapuram. It is a web based expert system that provides solutions to various problems faced by cassava farmers. It gives the information about different varieties of cassava, nutrient management, plant protection and online market details.

Oushadam: An expert system developed for cassava by Central Tuber Crops Research Institute, Thiruvananthapuram. Like other crops, cassava is vulnerable to pests and diseases that can cause heavy yield losses. It is an on line diagnostic system to identify correctly the diseases, pests or nutrient related problems affecting and suggests the remedial measures.

9.3. Some expert systems developed at CLAES

CLAES-The Central Laboratory for Agricultural expert Systems, Egypt, which helps farmers to optimize the use of resources and maximize agriculture production has developed many expert systems. (Divya and Sreekumar, 2014). Some of which are mentioned below:

Cuptex: An expert system developed for cucumber crop production. It mainly aims diagnosis, disorder treatment, irrigation scheduling, and plant caring.

Citex: An expert system developed for orange production. It mainly includes assessment and evaluation of farms, disorder diagnosis, disorder treatment, irrigation scheduling of orange.

Neper Wheat: An expert system developed for irrigated wheat management. It includes the production and scheduling management.

Tomatex: An expert system developed for tomatoes. It is developed for disorder diagnosis, to conclude causes of user complaints and verifies user assumption. Disorder treatment is to advice user about treatment operation of the infected plant.

Limex: A multimedia expert system developed for lime production.

Table 1. Difference between conventional and expert system of extension

Conventional extension	**Expert system of extension**
Universal approachability of same information is a problem	Universal approachability of same information is possible
Information without considering needs and resources	Information based on their needs and resources
Cost - benefit analysis is difficult	Cost - benefit analysis is easy

Information flow depends on availability of agent	Information through Cyber Cafe at any place at any time
Manual and fragmented information	Compact and interconnected

10. Benefits and limitations of expert systems

10.1. Benefits

- ✓ Efficient use of available resources and infrastructure
- ✓ Awareness of cost benefit ratio before actual adoption
- ✓ Appropriate decision making
- ✓ Encouraging diversification
- ✓ Encouraging quality production

10.2. Limitations

- ✓ Limited domain specific knowledge
- ✓ Lack of knowledge representation mechanism
- ✓ User has to describe the problem in formal language only
- ✓ Experts needed to setup and maintain system
- ✓ Development cost is too high

11. Case study

11.1. The evaluation and impact of NEPER wheat expert system

Rafea and Mahmoud (2001) studied the laboratory and field evaluation results of NEPER Wheat expert system. The laboratory evaluation showed that NEPER performance is comparable with human experts. Field evaluation has revealed that NEPER has good economic and

environmental impacts. The field testing results have also shown that NEPER is usable, applicable and needed.

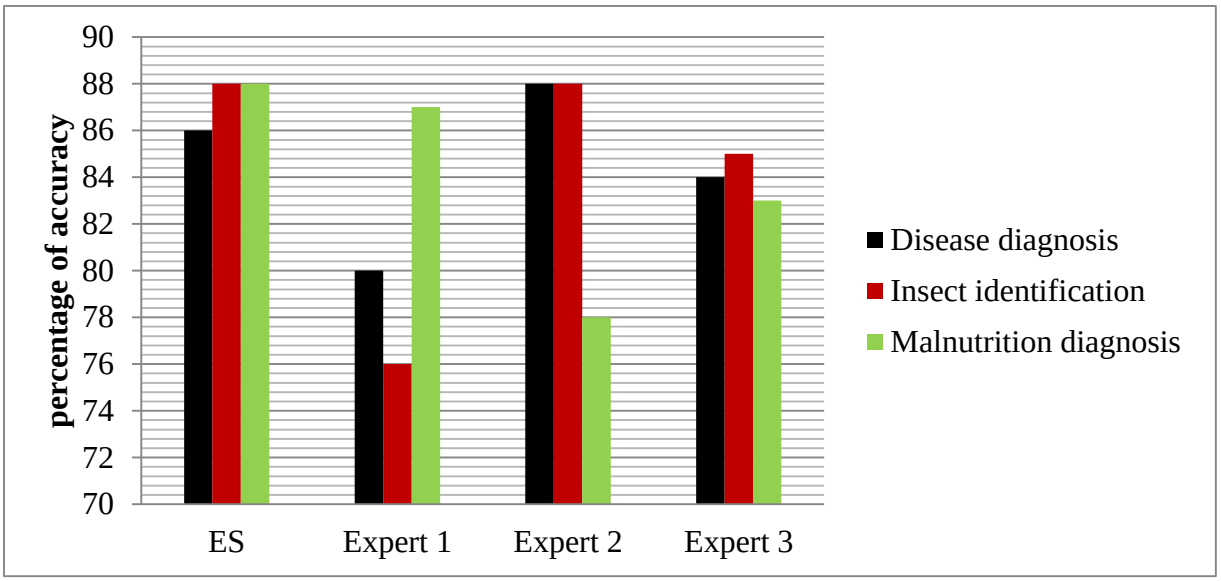

Fig. 2 Evaluation scores of NEPER diagnosis

Fig.2. Gives the evaluation scores of NEPER diagnosis subsystem performed better than human expert in the insect and malnutrition specialties, and its score in the disease diagnosis results (86%) was equivalent to those of the best human expert.

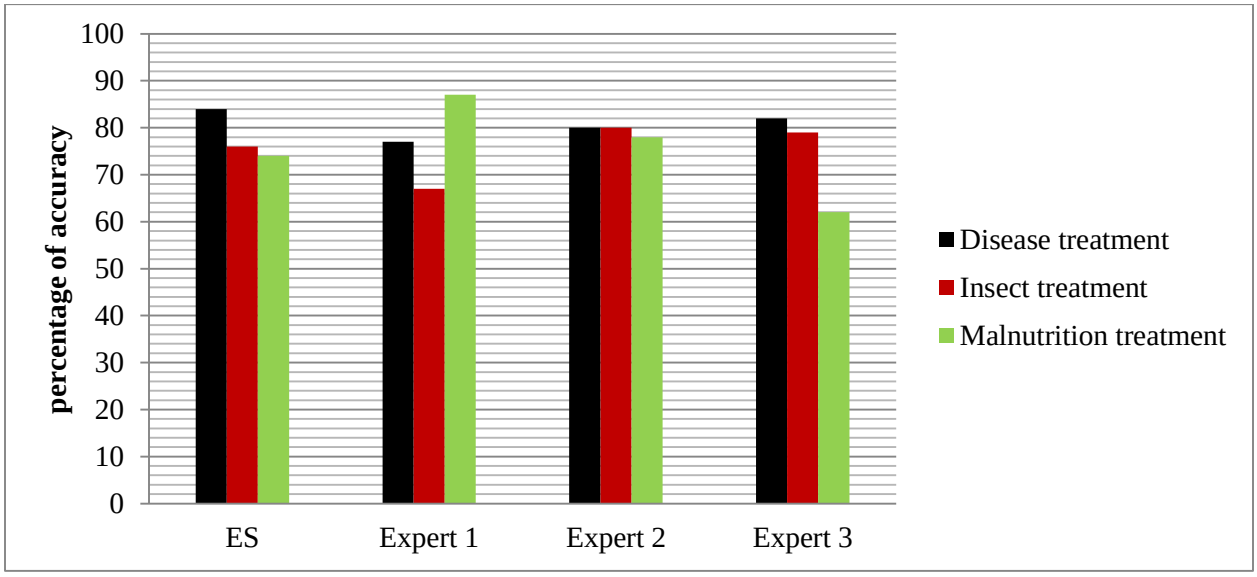

Fig. 3 Evaluation scores of NEPER treatment

Fig.3. Gives the evaluation scores of NEPER treatment subsystem performed better than human expert in disease treatment, and its score in the insect and malnutrition treatment are 0.95 and 0.85 respectively of the best expert-group. After this experiment, NEPER has been trained to reach the scores of the best experts.

11.2. DIAGNOS-4 expert system - a participatory assessment

Helen (2008) studied the experimental design among the extension personnel and farmers from Palakkad District of Kerala. DIAGNOS-4 expert system was selected. Mean score, percentage analysis, Kendall's Coefficient of Concordance, t-test were the statistical tools used.

Table 2. Problem solving capacity of agricultural expert systems as assessed by extension personnel

No.	**Experienced problem**	**Solutions received**					
		HE alone		AES alone		AES + HE	
		Mean score	Percentage	Mean score	Percentage	Mean score	Percentage
1	Rice Stem borer	3.44	74.14	3.03	65.30	4.23	91.16
2	Bacterial leaf blight	3.26	84.52	2.14	89.70	3.42	93.19
3	Brown plant hopper	3.46	58.31	2.14	55.48	3.56	97.00
4	Gall midge	3.32	73.78	3.41	75.78	3.91	86.89
5	Leaf folder	4.07	90.44	4.32	96.00	4.46	99.11
6	Ear head bug	3.12	93.60	3.20	96.00	3.28	98.40
	Mean	3.45	79.13	3.04	79.71	3.81	94.29

Table 2. Shows the problem solving capacity of AES accessed by extension personnel on rice crop, on stem borer problem, and found that human experts and AES provided solutions with 74.14 and 65.30 percent accuracy respectively, while in combination, it gave 91.16 percent accuracy. When the overall percentage of solutions offered by AES was worked out, it was almost on par with the solutions given by human expert. However, it served better in combination with human experts.

11.3. Effectiveness of selected agricultural expert systems in Kerala

Kishore and Thomas (2016) studied on the assessment of the effectiveness index of expert system applications in agriculture with special reference to KAU-Fertulator and e-Crop doctor, developed by Kerala Agricultural University. A survey was conducted among three targeted segments of Kerala extension professionals with a total of 100 respondents who were actively involved in the field of agriculture.

Table 3. Effectiveness of agricultural expert systems

SI. No	**Application**	**Extension professionals (SDA).n=40**		**Front line extension Personnel. (FLEP from KVK&NGOs) n=30**		**Scientists N=30**		**Total N=100**	
		Mean scores	Rank	Mean scores	Rank	Mean scores	Rank	Mean scores	Rank
1	Quick availability and opportunity of the expert system to programme itself	3.5	4	3.66	2	3.53	4	10.69	3
2	Expert systems ability to exploit a considerable amount of	3.62	2	3.56	3	3.66	2	10.84	2

	knowledge								
3	Reliability of the expert system	3.37	7	3.53	4	3.36	5	10.26	5
4	Scalability of the expert system	3.42	6	3.43	7	3.26	7	10.11	7
5	Pedagogy(As a means to effective learning through expert system)	3.65	1	3.7	1	3.73	1	11.08	1
6	Expert systems ability on preservation and improvement of knowledge	3.52	3	3.46	6	3.56	3	10.54	4
7	Expert systems ability to address the new areas neglected by conventional computing	3.45	5	3.5	5	3.3	6	10.25	6

Table 3. Reveled that pedagogy was the highly rated parameter, which secured first rank with a mean score of 11.08 followed by ability of expert systems to exploit a considerable amount of knowledge with a mean score of 10.84.

12. Conclusion:

Many agricultural organizations and agencies have developed agricultural expert systems to help farmers and other stakeholders in agriculture. Consequently a number of expert systems are available at present in aspects related to production and management of crop agriculture and allied sectors. Studies have shown that the expert systems are effective tools for learned decision making. When the agricultural expert system is combined with human expert, it gives the best results in delivering the services to the farmers, agricultural extension workers and other stakeholders. Thus, expert system of extension can provide the demand based information to millions of farmers if used efficiently. Farmers, agricultural extension workers and students will be greatly benefited with this online extension system in transfer of technology in the years to come.

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14. Discussion:

what are the expert systems available in Malayalam?

Ans: e-Crop doctor, Fertulator, Agri Almanac and Seed rate and spacing are some of the expert systems available in Malayalam.

What are the mostly used expert systems in Kerala?

Ans: As of now no studies are there, but it is said that the e-crop doctor and Fertulator expert systems are used more by the farmers and the extension personnel's in Kerala.

15. Abstract

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COLLEGE OF HORTICULTURE, VELLANIKKARA
Department of Agricultural Extension
EXTN 591: Master's Seminar

Name : M. Mahesh Yadav
Admission No. : 2018-11-127
Major Advisor : Dr. A. Sakeer Husain

Venue : Seminar Hall
Date : 17-01-2020
Time : 10.00 am.

Expert systems for demand driven extension

Abstract

Agricultural production has evolved into a complex business which requires collection of knowledge from different sources. In order to remain competitive, the modern farmer often relies on agricultural specialists and advisors for decision making, whose assistance is not always available when the farmer needs it. To meet this challenge, expert systems were developed and identified as a powerful tool with extensive potential in agriculture, since it integrates information from a number of experts.

Agricultural Expert Systems (AESs) are tools for agricultural management since they can provide site specific, integrated and interpreted advice that farmers and consultants need to efficiently manage agricultural concerns (Rajotte *et al*., 2005). Text, image, video and audio are the forms of media on which information can be found, and the role of information technology is to devise tools to store and retrieve this information. Several systems have been designed for crop production, diagnosis, and crop management (Joy and Sreekumar, 2014).

Development of expert systems had started since 1960s. Dendral was the early expert system developed in 1965, which was a chemical analysis expert system. In the field of agriculture, POMME was the first expert system, developed in Egypt. In India, Rice Crop Doctor developed by the National Institute of Agricultural Extension Management (MANAGE) was the pioneer expert system in agriculture, where as in Kerala it was AGREX developed by Kerala Agricultural University (Boniface and Husain, 2006).

There are four essential components for a full-fledged expert system *viz*., knowledge acquisition module, knowledge base, inference engine and explanatory interface (Bahal *et al*., 2006).

Expert systems are developed for meeting various purposes such as diagnosis, repair, interpretation, forecasting, design and planning, monitoring, control *etc.* (Waterman, 1985). In agriculture, expert systems is applied in crop selection, soil management, nutrient management, plant disease and pest management, weed management and estimation of crop yield (Rafea and Mahmoud, 2001). Some of the agricultural expert systems developed in India are RubSIS, Rubberclinic, AgriDaksh, EXOWHEM, Oushadam, Cassava expert System, Paddy expert system, Coconut expert system, Sugarcane expert system, Banana expert system, Finger millet expert system *etc.*, while the expert systems developed by Kerala Agricultural University

includes NRSR, Crop 9 DSS, e-Crop doctor, Fertulator, Seed rate and spacing, Agri Almanac, and e-DID.

Studies have shown that expert systems are effective tools for learned decision making. NEPER diagnosis subsystem performed better than human expert in the insect and malnutrition specialties, and its score in the disease diagnosis results (86%) was equivalent to those of the best human expert (Rafea and Mahmoud, 2001). Kishore and Thomas (2016) reveled that pedagogy was the highly rated parameter, which secured first rank with a mean score of 11.08 followed by ability of expert systems to exploit a considerable amount of knowledge with a mean score of 10.84. Helen (2008) studied the problem solving capacity of AES accessed by extension personnel on rice crop, on stem borer problem, and found that human experts and AES provided solutions with 74.14 and 65.30 percent accuracy respectively, while in combination, it gave 91.16 percent accuracy.

Thus, the expert system of extension can provide the demand based information to millions of farmers if used efficiently. Farmers, agricultural extension workers and students will be greatly benefited with this online extension system in transfer of technology in the years to come.

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