Journal of Computer Science and Applications.
Volume 3, Number 1 (2011), pp. 59-71

http://www.irphouse.com

# Expert Systems in Agriculture: A Review

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**Abstract**

Now-a-days, expert system is widely used in agriculture exclusively for diagnosing and managing pests. These pest problems are mainly dependent upon human experts for their diagnosis and getting recovery. The involved human experts are very scarce, inconsistent in their day-to-day decisions, unable to comprehend large amounts of data quickly, unable to retain large amounts of data in memory, subject to deliberate or inadvertent bias in their actions and can deliberately avoid decision responsibilities. Human experts are not always available whereas the computer based expert system can be used anywhere, any time. Expert system offers an environment where the good capabilities of humans and the power of computers can be incorporated to overcome many of the limitations. Expert system increases the probability, frequency and consistency of making good decisions, additive effect of knowledge of many domain experts, facilitates real-time, low-cost expert-level decisions by the non-expert, enhance the utilization of most of the available data and free the mind and time of the human expert to enable him or her to concentrate on more creative activities. Under these backgrounds, expert system has been developed in various agricultural crops like rice, wheat, tomato, rapeseed and mustard, mango etc. in order to diagnose various pests and taking management decisions for the benefit of farmers.

**Keywords:** Expert system, agriculture, diseases, rice, wheat, tomato, rapeseed-mustard, mango.

## Introduction

An expert system is defined as “a computer program designed to model the problem solving ability of a human expert” (Durkin, 1994). It is also defined as “a system that uses human knowledge captured in a computer to solve problems that ordinarily require human expertise”. An intelligent computer program that uses knowledge and inference procedures to solve problems that was difficult enough to acquire significant human expertise for their solutions. It is a computer application that solves complicated problems that would otherwise require extensive human expertise. To do so, it simulates the human reasoning process by applying specific knowledge and interfaces. Expert system also uses human knowledge to solve problems that normally would require human intelligence. It represents the expertise knowledge as data or rules within the computer. These rules and data can be called upon when needed to solve problems. Books and manual guides have a tremendous amount of knowledge but a human has to read and interpret the knowledge for it to be used. The idea behind creating an expert system is that it can enable many people to benefit from the knowledge of one person - the expert.

Expert systems typically have three components *viz.*, knowledge base, inference engine and user interface. The knowledge base is the component that contains the knowledge obtained from the domain expert. Normally, the way of representing knowledge is using rules. The inference engine is the component that manipulates the knowledge found in the knowledge base as needed to arrive at a result or solution. The user interface is the component that allows the user to query the system and receive the results of those queries. Many expert systems also have an explanation facility which explains why a question was asked or how a result or solution was obtained.

There are several major application areas of expert system such as agriculture, education, environment and medicine. These four applications are widely used among the practitioners. In this paper, we shall review in detail about the use of expert system in agriculture. The components and application of expert system for agriculture is same as that of other three applications. The experience and knowledge of a human expert is captured in the form of IF-THEN rules and facts which are used to solve problems by answering questions typed at a keyboard attached to a computer on such diversified topics, for example, in pest control, the need to spray, selection of a chemical to spray, mixing and application, optimal machinery management practices, weather damage recovery such as freeze, frost or drought, *etc*. Now-a-days expert system in agriculture is employed more for diagnosis and management of economically significant pest problems like diseases and insects of crop plants.

## Wheat Pakistani Expert System

Khan *et al.* (2008) established a web-based expert system for wheat crop in Pakistan. They presented a web-based expert system for wheat crop in Pakistan. Wheat is one

of the major grain crops in Pakistan. According to the Pakistan Agricultural Research Council (PARC), per capita wheat consumption of the country is 120 kg a year (PARC, 1989). It is cultivated in vast areas of Punjab followed by Sindh in Pakistan and ranked first as a cereal crop in the country. The rule-based expert system covers two main classes of problems namely diseases and pests, normally encountered in wheat crop. The expert system is constructed using e2gLite™ expert system shell available freely on the internet. This web-based expert system shell allows a JAVA interface to process its input and output sets. The expert system can act as a powerful tool with extensive potential in agriculture especially in situations where agricultural specialist assistance is not readily available when the farmers need it. The expert system is intended to help the farmers, researchers and students and provides an efficient and goal-oriented approach for solving common problems of wheat. The expert system gives results that are correct and consistent. In Pakistan several diseases are reported to occur (Anonymous, 2000).The important wheat diseases in Pakistan are Black Stem Rust of Wheat, Leaf Rust of Wheat, Bacterial Leaf Blight, Flag Smut of Wheat, Bunt of Wheat, Root Knot and Bacterial Leaf Streak.

## Methodology

The first step in the development of any expert system is problem identification. The problem here is a diagnostic problem aimed to identify ailments in the wheat using symptoms of diseases and pests. The problems occur frequently and the consequences on farmer's financial status are enormous. The demand for help is increasing rapidly. Experts are there to help but sometimes they are not readily available, especially in rural areas. Therefore expert systems are needed in those rural areas where the help to the farmers is not readily available. Diagnosis or diagnostic problem solving is the process of understanding what is wrong in a particular situation. Thus gathering of information and then interpreting the gathered information for determining what is wrong are of central importance in diagnostic problem solving (Lucas, 1997).

The knowledge base is the core component of any expert system. The first task in the development of knowledge base is knowledge acquisition. Knowledge acquisition (Hart, 1986) is considered as one of the most important phases in the expert system development life cycle (Miskoff, 1995). Knowledge acquisition is to obtain facts and rules from the domain expert so that the system can draw expert level conclusions. Some commonly used approaches of knowledge acquisition are interviews, observations, taking experts through case studies and rule induction by machines (Turban, 1995) .After the knowledge acquisition begins the process of representing that knowledge. The knowledge base for e2glite expert system shell consists of simple if-then rules. The rules are usually fired on the basis of internal logic of inference engine. Forward chaining and backward chaining techniques represent the fundamental reasoning approaches implemented in rule-based expert systems.

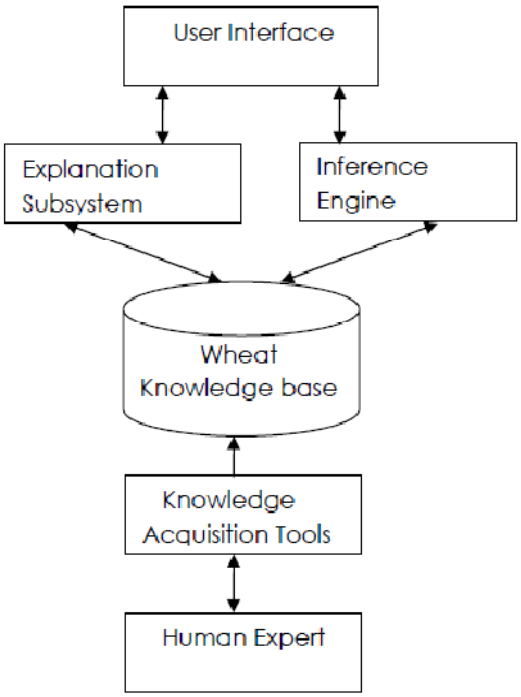


**Figure 1:** Wheat Pakistani Expert System Architecture.

## Mango Expert System

Prasad *et al.* (2006) formulated an expert system *viz.*, AMRAPALIKA for diagnosing 14 different pests including eight diseases and six insects in Indian mango variety. The expert system is developed for important diseases like Powdery mildew, Black spot, Anthracnose, Red rust, Die back, Bacterial spot, Sooty mould and Malformation and insects like Shoot-borer, Red ants, White ants, Mealy bug, Mites and Fruit fly. In India, this fruit is grown in the area of 1.23 million ha (70% fruit-growing area) with an annual production of 10.99 million tones, which accounts for 57.18% of the total world production (Negi, 2000). Although India is the biggest producer of mango in the world, the per capita production is low and it is estimated that more than 20–22% of the total production of fruits is lost due to spoilage at various post harvest stages (Agro food processing technology, 2020). They emphasized application of expert system in Indian fruiticulture and described development of a rule-based expert system, using expert system Shell for Text Animation (ESTA), for the diagnosis of the most common diseases and insects occurring in Indian mango. The mango expert system makes diagnosis on the basis of responses of the users made against queries related to particular disease or insect symptoms. The knowledge base of the system contains knowledge about symptoms and remedies of 14 pests of Indian mango tree appearing during fruiting season and non-fruiting season. The picture base of the system contains pictures related to symptoms and are displayed along with the query of the system.

## Methodology

Diagnostic problem solving has been formalized in a cyclic process of abduction, deduction and induction in the light of hypothetical reasoning. Logic has been one of the oldest tools for diagnostic problem solving and logic based different diagnostic approaches like abductive diagnosis, deductive diagnosis, consistency-based diagnosis, etc. This expert system uses logical models of visual symptoms and ailments as the classification rules expressed in the syntax of ESTA. The rule-based strategy has been successfully used, in several other diagnostic expert systems (Hanson and Widom, 1993; Clancy, 1983). The rule based approach in backward chaining for knowledge representation has been chosen here too. The choice of backward chaining is due to the fact that it is goal directed and resembles the reasoning process of the diagnosis. The next effort is to integrate nutrient deficiency module with this knowledge base.

In the developing countries where lots of farmers are not competent to English language, such expert systems are needed to be developed in regional languages and are required to make available to village area through blocks or village administration unit so that farmers get a chance to develop their own expertise. However, expert system based on hypermedia techniques, the possibility of communication by text, pictures and sound, will be highly beneficial and acceptable. Adding speech interface to the system may be proved to be more beneficial for the farmers of the remote area. Even illiterate farmers can interact with speech interface based expert system and get benefits. However, spoken language technology is still in infancy and is not advanced enough to provide such interfaces.

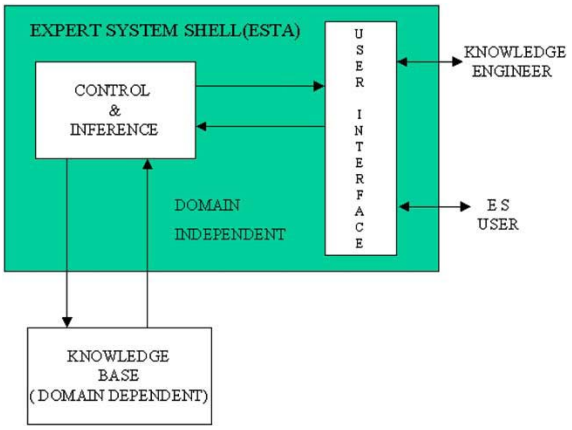


**Figure 2:** Mango Expert System Architecture.

## Rice Expert System

In India, Sarma *et al.* (2010) developed an expert system in order to diagnose and manage the diseases occurring in rice crop. They presented an architectural framework of an expert system in the area of agriculture and describe the design and development of the rule based expert system, using the shell ESTA. The designed

system is intended for the diagnosis of common diseases occurring in the rice plant. The rice expert system is a computer program normally composed of a knowledge base, inference engine and user-interface. This expert system facilitates different components including decision support module with interactive user interfaces for diagnosis on the basis of responses of the users made against the queries related to particular disease symptoms. ESTA programming is based on logic programming approach. The system integrates a structured knowledge base that contains knowledge about symptoms and remedies of diseases in the rice plant appearing during their life span. An image database is also integrated with the system for making the decision support more interactive. The pictures related to disease symptoms are stored in the picture database and the intelligent system module prompts these with the interface based on rule based decision making algorithms. The system has been tested with domain dataset and results given by the system have been validated with domain experts.

## Methodology

In an expert system development, knowledge base development is the most important part. The quality of an expert system depends on its knowledge base. Knowledge Base development with the help of domain specific expert in this expert system is developed with ESTA. The process of developing expert system using ESTA is a multi-step process which aims at developing a domain specific knowledge base. The steps for developing knowledge base in this system are identification of the input problem, knowledge acquisition and representation of knowledge into the knowledge base. Diagnosis of common diseases of rice, is also used to acquire knowledge about rice diseases in this expert system development (Elazegui and Islam, 2003).

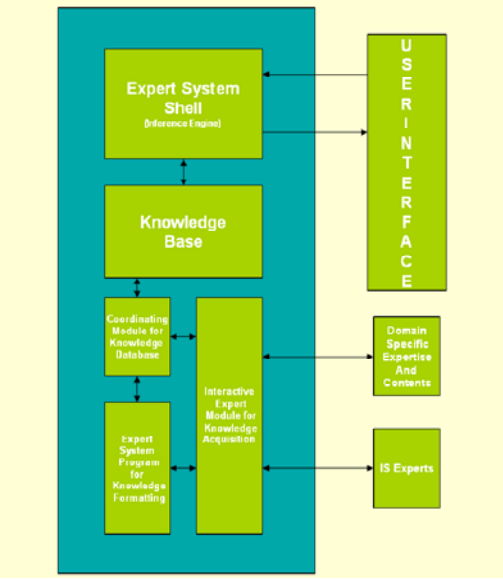


**Figure 3:** Rice Expert System Architecture.

## Tomato Expert System

A web based tomato crop expert information system was developed by Babu *et al.* (2010) in India. The tomato crop expert advisory system is aimed at a collaborative venture with eminent Agriculture Scientist and experts in the area of tomato plantation with an excellent team of computer engineers, programmers and designers. This expert system contains two main parts *viz.,* tomato information system and tomato crop expert system where in information system, the user can get all the static information about different species, diseases including viruses, pests of tomato fruits and plants, their symptoms, preventions and chemical controls. In advisory system, the user is having an interaction with the expert system online. The user has to answer the questions asked by the expert system. Depends on the response by the user, the expert system decides the specific disease or pest and displays its control measure. This tomato crop information expert system deals with different varieties of tomato crop, identification of various diseases and pests generally occurs to tomato crop based on the symptoms.

## Methodology

The rule based expert system validates the symptoms of the tomato crop using the techniques of ID3 Algorithm and some optimization algorithms. This is a web based expert system with java server pages (JSP) as the front end and MySQL as the backend. Tomato crop expert advisory system is aimed at a collaborative venture with eminent Agriculture Scientist and Experts in the area of Tomato Plantation with an excellent team of computer Engineers, programmers and designers. The program is divided into two aspects 1) Information System 2) Advisory System In Information system, the user can get all the static information about different species, Diseases, Symptoms, chemical controls, Preventions, Pests, Virus of Tomato fruits and plants. In Advisory System, the user is having an interaction with the expert system online. The user has to answer the questions asked by the Expert System. Depends on the response by the user the expert system decides the disease and displays its control measure of disease.

This web application is expected to have the following features: 1) This web application provides time-to-time updates of tomato information to the users at their doorsteps regarding diseases, virus and its control measure, which leads to good yields. 2) This site contains four major sections named Information Systems of Tomato crop, Tomato Advisory System, other services related to web application and an additional feature is links to other agriculture systems. 3) The web directory service, articles and the discussion forum service provided in the website will help the tomato fraternity in a greater way to interact each other to produce better findings in the area of tomato field.

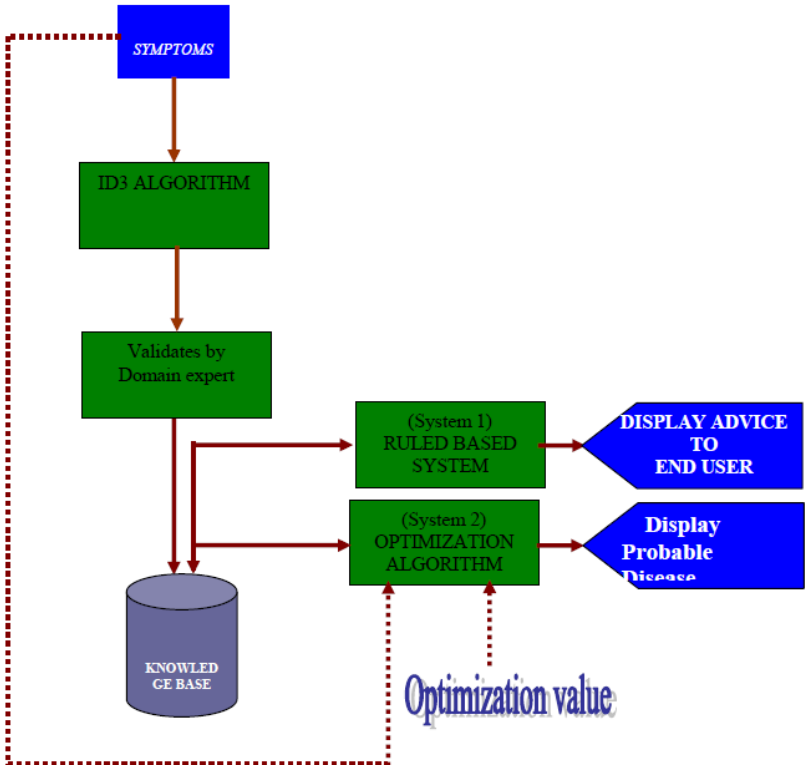


**Figure 4:** Tomato Expert System Architecture.

## Rapeseed-Mustard Expert System

Vinod *et al.* (2008) developed an image based rapeseed-mustard disease expert system in India. The diagnosis and control measures of economically important diseases like Alternaria blight, white rust and white rot , downy mildew complex, powdery mildew, white rot of rapeseed-mustard were effectively performed by using this expert system. It is estimated that, on average harvest seed yield losses due to *Alternaria* blight range from 5-15% and can reach 47% (Kolte, *et al.*, 1987). White rust in B. juncea can result in yield losses of up to 47% (Kolte, 1985), Rot of mustard has become important in recent times in India and elsewhere with high disease incidence and causes up to 40 % yield losses leading to discouragement of growers of the crop (Chattopadhyay *et al.*, 2003) A panel of human experts in the field of rapeseed mustard diseases and published materials were consulted to collect the knowledge about the rapeseed-mustard diseases on different part of plant and their management practices. Plant diseases appearances were classified into six classes *viz.*, flower, stem, leaves, pods, root and whole plant. The high quality colored images and video clip of various symptoms of diseases were captured by using modern digital/video cameras. Visual symptoms of pests and plant diseases can be captured by electronic devices for quick diagnosis (Xin *et al.*, 2001) .System design composed of several basic components: a user interface, a database, a knowledge base and an inference mechanism. System development usually proceeds through several phases

including problem selection, knowledge acquisition, knowledge representation, programming, testing and evaluation (Vinod *et al.*, 2004).

## Methodology

A panel of human experts in the field of rapeseed mustard diseases and published materials were consulted to collect the Knowledge about the rapeseed-mustard diseases on different part of plant and their management practices. Plant diseases appearances were classified into six classes: flower, stem, leaves, pods, root and whole plant. The high quality colored images and video clip of various symptoms of diseases were captured by using modern digital/video cameras. System design composed of several basic components such as user interface, a database, a knowledge base and an inference mechanism. Design methodology and system implementation knowledge base dealt with information like data of characteristic of diseases, photographs of symptoms of different diseases on different parts and the data of management of these diseases were collected from the scientists especially pathologists, extension workers as well as published literature and then coded with the object oriented programming language such as Visual Basic 6.0 as front-end, and MS-Acccess-2000 as backend, has been used to develop the software.

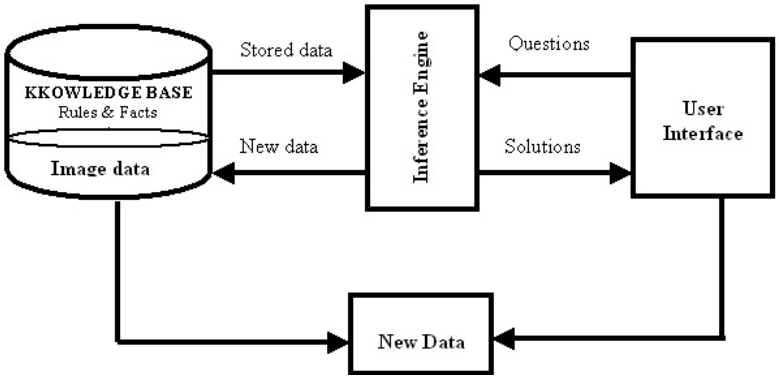


**Figure 5:** Rapeseed-Mustard Expert System Architecture.

## Advantages of Expert System

The significant advantages in the above mentioned expert systems of different crops are given below.

- The system can be used by extension personnel, researchers and farmers to identify crop diseases and enable to proceed their management.
- User can easily identify the disease on the basis of photographs of symptoms and text descriptions of disease.
- The user friendly software developed using windowing environment, thus provides enough facilities to identify the disease and to suggest the remedy conveniently.

- Provide consistent answers for repetitive decisions, processes and tasks.
- Hold and maintain significant levels of information.
- Reduce employee training costs.
- Centralize the decision making process.
- Create efficiencies and reduce the time needed to solve problems.
- Combine multiple human expert intelligences.
- Reduce the amount of human errors.
- Review transactions that human experts may overlook.

## Limitations of Expert System

Various limitations in the Expert Systems of different crops are listed out below.

- Many farmers in the country are illiterate and knowledge of computers in rural areas is still unreached.
- It needs to be expanded and updated to accommodate new diseases and ailments of important crops in the locality.
- There is a need to include other disease diagnosis techniques such as, laboratory tests, soil test report, tissue test, plant analysis report, etc.
- The integration of nutrient deficiency module with the knowledge base needs to be included
- If the picture used in expert system is poor quality, the confusion in diagnosis of the problem will be happened and ultimately decision making will not be done properly. Therefore, the picture quality is required to be enriched.
- The complexities arising in managing rules for large knowledge base. It is difficult to write knowledge-based rule and place them in proper sequence for larger number of parameters. Verification of large numbers of rule-based system is difficult.
- Since the computer is lack of common sense, the programmer should develop the expert system in efficient way. If he or she does mistake, everything will be collapsed.
- In the developing countries, lots of farmers are not competent to English language, such expert systems need to be developed in regional languages.
- The expert systems are to be demonstrated to village area through blocks or village administration unit so that farmers can get a chance to develop their own expertise.
- Adding speech interface to the system may be proved to be more beneficial for the farmers of the remote area.
- Will not be able to give the creative responses that human experts can give in unusual circumstances.
- Lack of flexibility and ability to adapt to changing environments.
- Not being able to recognize when no answer is available.
- Knowledge acquisition remains the major bottleneck in applying expert system technology to new domains.
- Maintenance and extension of a rule base can be difficult for a relatively large

rule base (beyond 100 rules).

- Expert systems are not as compact as neural network and genetic algorithm systems.
  This makes them harder to embed in other systems, as the inference engine and working memory must be part of the system at run-time.

## Comparison of Important Expert Systems

The main differences between the expert systems of mango, rapeseed –mustard and tomato are given as follows.

**Table1:** Comparision of Expert Systems.

| S. No | Contents | Rice Expert System | Wheat Expert System | Rapeseed-Mustard Expert System | Tomato Expert System | Mango Expert System |
|---|---|---|---|---|---|---|
| 1 | Problems covered | Common diseases in rice | Diseases and pests, normally encountered in wheat crop. | Alternaria blight, white rust and White rot, downy mildew complex, powdery mildew, white rot of rapeseed-mustard | Common diseases in tomato | 14diseases in Indian mango tree |
| 2 | Location in which Expert system is Developed | Assam, India | Pakistan | India | Hyderabad, Andhra Pradesh, India | Bihar, India |
| 3 | Language used | Expert System Shell for Text Animation(ESTA) Tool | e2gLite™ expert system shell | Visual Basic as front-end and Microsoft Access -2000 as back-end software. | Java Server Pages (JSP)as front end and MySQL as backend | Expert System Shell for Text Animation (ESTA) Tool |
| 4 | Components used | Identification of Input Problem, Knowledge acquisition consists of Interactive Expert Module, Expert System program | Diagnostic Problem solving, Knowledge acquisition and knowledge representation | User interface, Database, knowledge base and an inference mechanism. | Information system, Advisory system, rule based system | Problem definition and diagnostic expertise modeling, Knowledge acquisition, Knowledge |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | and Coordinating Module, Knowledge representation using rule based engine | | | | representation using simple if-then rules in backward chaining. |

## Conclusion

The farmers often rely on agricultural specialists and advisors to provide information for decision making to get rid of problems related to pests and diseases. But, due to non availability of agricultural specialists or extension workers, the decision making process will be delayed. In such cases, the losses due to problems will be increased more within the delayed time. Therefore, the time saving and immediate decision making can be done effectively by using expert system. The expert systems in agriculture help a lot in increasing the crop production and reducing the yield losses. The successfully developed expert systems should be demonstrated to farmers for the benefit of them. The impact studies of expert systems in different crops are required to be incorporated in due course.

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