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Expert System Applications in Agricultural Extension and Advisory Service

Santosh Singh*, Rajendra Singh Negi

Department of Rural Technology, HNB Garhwal University Srinagar Garhwal, Uttarakhand

*singhrawat.santosh@gmail.com

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ABSTRACT

Expert systems represent one of the most significant applications of artificial intelligence in the agricultural sector. These systems are designed to simulate the decision-making ability of human experts by using structured knowledge bases and rule-based inference mechanisms. In developing countries like India, where farmers face challenges such as pest and disease outbreaks, nutrient deficiencies, unpredictable weather, and limited access to extension personnel, agricultural expert systems play a vital role in providing timely and scientific advisory support. This article highlights the importance, components, and applications of agricultural expert systems in enhancing farming practices and strengthening extension services. Various expert systems developed in India, such as AGREX, Rice Crop Doctor, EXOWHEM, AMRAPALIKA, Coconut Doctor, Sugarcane Doctor, and Tomato Expert System, demonstrate the growing adoption of knowledge-based technologies in crop management. In addition, mobile-based advisory apps such as mKisan, Plantix, Kisan Suvidha, and AgroStar have expanded the reach of expert guidance to rural farmers. Expert systems offer several advantages including quick problem diagnosis, efficient resource utilization, improved decision-making, and increased productivity. However, limitations such as illiteracy, lack of computer awareness, language barriers, and the need for continuous updating remain major constraints. Expert systems serve as powerful tools for bridging the knowledge gap between agricultural research and farmers, contributing to sustainable and profitable agriculture.

Keywords: Agriculture, Artificial Intelligence, Extension, Expert systems, Farmers.

1. INTRODUCTION

The development of expert systems represents a transformative advancement for agricultural extension services. These sophisticated digital tools, which encapsulate specialized knowledge on crops, pest management, soil health, and best farming practices, will prove invaluable in designing targeted and effective extension programmes. By providing a centralized, reliable knowledge base, they streamline the planning and customization of advisory content, thereby conserving the scarce and precious time of both extension personnel and farmers. To maximize their benefit, it is imperative that these expert systems be deployed and installed across all regional and local agricultural extension centers (**Babu 2006; Sivakami and Karthikeyan 2009; Singh and Hussain 2018**). Such widespread implementation ensures that farmers have direct, intuitive, and easy access to vital information precisely when they need it, democratizing expert advice and empowering them to make informed, on-the-spot decisions (**Das and Nayak 2013; Mishra and Deep 2014; Prangya et al., 2024**). Expert system are also referred to as Knowledge Based Systems (KBS) (**de Hoog 2019**).

This addresses a critical and persistent practical challenge currently faced by extension workers: the overwhelming demand for their expertise. A single agent cannot physically or simultaneously meet the diverse, individual enquiries of all farmers in their jurisdiction, leading to delays, information bottlenecks, and unmet needs. The installation of this comprehensive expert system package will significantly minimize this constraint. By handling routine and frequently asked questions, the system acts as a force multiplier, allowing extension workers to focus their human expertise on more complex, site-specific problems and personalized guidance. This synergy between digital tools and human agents will enhance the overall efficiency, reach, and quality of agricultural advisory services (**Sarma et al., 2010; Rani et al., 2011; Naika et al., 2021; Prangya et al., 2024; Bahal et al., 2006; Umadikar et al., 2014**).

2. NEED FOR AGRICULTURAL EXPERT SYSTEM

Agriculture is one of the most important sectors of the economy, especially in developing countries like India. Farmers face many challenges such as unpredictable weather, pest and disease outbreaks, lack of technical knowledge, and limited access to agricultural experts. In this context, Agricultural Expert Systems are needed to provide scientific support and improve decision-making in farming. Agricultural expert systems are highly needed because agricultural experts are limited in number and cannot provide timely support to all farmers, particularly in rural and remote areas. These systems play an important role in improving farmers' decision-making by offering accurate guidance on crop selection, planting time, nutrient management, and disease control (**Sriram, and Philip 2016; Islam et al., 2024; Singh and Hussain,2018; Mishra & Deep 2014**). They also help in the early diagnosis of crop problems such as pest attacks, diseases, and nutrient deficiencies, thereby reducing crop losses (**Ballea et al., 2014; Titiya and Shah 2018**). Expert systems promote efficient resource management by advising on the proper use of water, fertilizers, and pesticides, supporting sustainable agricultural practices. By providing scientific recommendations, they contribute to increasing productivity and profitability through higher yields and improved farm income (**Umadikar et al., 2015; Mishra and Deep 2014**). Additionally, expert systems assist farmers in coping with climate and weather uncertainties by integrating weather data and delivering timely advisories to minimize risks. Overall, they bridge the knowledge gap by ensuring that farmers have quick and easy access to updated agricultural information and modern farming practices.

3. COMPONENTS OF AN EXPERT SYSTEM

An Expert System is an artificial intelligence (AI) program designed to replicate the reasoning and decision-making ability of a human expert. It consists of several key components that work together to solve complex problems and provide expert-level recommendations. The major components of an expert system are as follows:

- a) Knowledge Base:** The knowledge base is the core part of an expert system. It contains stored information, facts, rules, and expert experience related to a specific domain such as crop production, pest management, or soil fertility.
- b) Inference Engine:** The inference engine is the reasoning mechanism of the system. It applies logical rules to the knowledge base to draw conclusions and provide solutions. It works like the brain of the expert system.
- c) User Interface:** The user interface allows interaction between the farmer or user and the expert system. It enables users to input problems and receive advice or recommendations in an easy and understandable form.
- d) Explanation Facility:** This component helps the system explain its reasoning process. It provides justification for the recommendations, helping users understand why a particular decision or solution was suggested.
- e) Knowledge Acquisition Module:** The knowledge acquisition module is used to collect and update information from human experts, research findings, and databases. It ensures that the system remains accurate and up to date.
- f) Database:** Working memory stores temporary information during problem-solving, such as current field conditions, user inputs, or intermediate results.

4. SOME AGRICULTURAL EXPERT SYSTEMS DEVELOPED IN INDIA

AGREX: Center for Informatics Research and Advancement, Kerala has prepared an Expert System called AGREX to help the Agricultural field personnel and give timely and correct advice to the farmers. These Expert Systems find extensive use in the areas of fertilizer application, crop protection, irrigation scheduling, and diagnosis of diseases in paddy and post-harvest technology of fruits and vegetables.

FARM ADVISORY SYSTEM-Punjab Agricultural University, Ludhiana has developed the Farm Advisory System to give recommendations on the topic of Farm management. This expert system is designed to interact with users through a structured question-and-answer approach. The system asks the farmer or user a series of questions one by one, collects relevant information about farm conditions and management practices, and then provides suitable recommendations. The advisory support mainly focuses on improving decision-making in the area of farm management and overall agricultural business planning

Rice Crop Doctor: The National Institute of Agricultural Extension Management (MANAGE) has developed an expert system known as the Rice Crop Doctor to diagnose major pests and diseases affecting the rice crop and to suggest suitable preventive as well as curative measures. This system demonstrates the application of expert system technology in agriculture, particularly in rice production. The Rice Crop Doctor was developed as a prototype by considering a few important pests, diseases, and nutrient deficiency problems that significantly limit rice yield. It serves as a decision-support tool for farmers and extension workers to improve crop management practices.

Horticultural Research-based advisory software (U.H.R. Software) -The first software for use by the grape cultivators was prepared by the Indian Institute of Horticultural Research (IIHR), Bangalore. The spontaneous response to the software made them to undertake similar software for providing guidance to mushroom cultivators, which became popular, and a large number of growers are reported to use it regularly for getting solutions to their problems.

Expert System for Soybean Pest Management (SOYPEST): National Research Centre for Soyabean has developed the web based expert system, 'Soypest' for diagnosis and management of pests of soyabean. Agricultural Extension workers are reported to be utilizing this expert system.

EXOWHEM: Expert System on Wheat Crop Management is an expert system which includes all aspects of wheat production on India. The main goal of the system is to provide the users with all kinds of suggestions and advices regarding the wheat crop production. The system is designed as web based application by IASRI New Delhi that covers agricultural operations, fertilizer application, variety selection, as well as the economic benefits. It is purely a rule based expert system.

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.

AMRAPALIKA: The name is derived from the popular mango cultivar “**Amrapali**”, and the system provides advisory support to mango growers. The Expert System for the diagnosis of pests, diseases, and disorders in Indian Mango. The system makes diagnosis on the basis of response/responses of the user made against queries related to particular disease symptoms. A rule-based expert system is developed using Expert System Shell for Text Animation (ESTA). The knowledge base of the system contains knowledge about symptoms and remedies of 14 diseases of Indian mango tree appearing during fruiting season and non-fruiting season.

Banana Expert System: Banana is one of the oldest and most popular fruit. Banana is otherwise called ‘Apple of Paradise’. The Indo-Malayan region is believed to be the place of origin. India ranks first in terms of area and production, growing in about 4,90,700 ha with an annual production of 168,13,500 mt, sharing about 17% of global production. In Tamil Nadu banana is grown in almost all the districts with more area under the districts like Trichy, Tuticorin, Coimbatore and Kanyakumari. TNAU's banana expert system is a mobile app that includes Irrigation Management, Nutrient Management for Banana, Crop Protection for Banana, Farm Implements for Banana, Post Harvest Technology for Banana, Marketing for Banana, Institutions and Schemes for Banana, Related Links for Banana. The expert system will also be synchronized with the existing KVK e-linking system for its implementation. The specific objective of the project is to develop expert system for crop and animal enterprises for instnsnt decision making.

Coconut Doctor Expert System: The Coconut Doctor is an important component of an expert system developed to support coconut growers in diagnosing and managing major pests, diseases, and nutrient deficiency disorders. This module includes key pests such as Rhinoceros beetle, Red palm weevil, Eriophid mite, Black headed caterpillar, Termite, Skipper, White grub, Scale insect, Grasshopper, Coried bug, Nut borer, Mealy bug, and Rat. In addition, major coconut diseases such as Leaf blight, Basal stem end rot, Stem bleeding disease, Bud root, Root wilt, and Leaf rot are also covered. The system further addresses deficiency disorders related to essential nutrients including **Nitrogen**, Phosphorus, Potassium, Boron, Manganese, and Magnesium.

Sugarcane Doctor Expert System: The Sugarcane Doctor is an important component of an agricultural expert system designed to assist sugarcane farmers in diagnosing and managing major pests, diseases, and nutrient deficiency disorders. This module includes key pests such as Top borer, early shoot borer, Internode borer, White flies, Mealy bug, White grub, Woolly aphid, Scale insect, Termite, Grasshopper, and Nematodes. It also covers major sugarcane diseases including Yellow leaf disease, Smut, Rust, Red rot, Ratoon stunting, Wilt, Sett rot, and Grassy shoot disease. In addition, deficiency disorders related to essential nutrients such as Nitrogen, Phosphorus, Potassium, and Iron are incorporated into the system.

Ragi Doctor Expert System: The Ragi Doctor is an important component of an expert system developed to support ragi (finger millet) farmers in identifying and managing major pests, diseases, and nutrient deficiency disorders. This module includes key pests such as Pink stem borer, Cut worm, Grasshopper, Leaf folder, Earhead caterpillar, Aphids, and Earhead bug. It also covers important ragi diseases including Blast, Seedling blight, Wilt, Smut, and Mottle streak. In addition, deficiency disorders related to essential plant nutrients such as Nitrogen deficiency, Phosphorus deficiency, and Potassium deficiency are incorporated into the system.

Maize Agri Daksh Expert System: Developed by Indian Agricultural Statistics Research Institute (IASRI) in collaboration with the Directorate of Maize Research, New Delhi (DMR). Maize Agri Daksh is an expert system developed to provide scientific advisory support for maize crop cultivation and management. The system is designed to assist farmers, extension workers, and agricultural professionals in making timely and accurate decisions related to maize production.

Barley Expert System: The Barley Expert System, developed in collaboration with the International Center for Agricultural Research in the Dry Areas (ICARDA), is a knowledge-based advisory tool for barley crop management. This expert system supports barley growers and extension personnel by recommending appropriate barley varieties, advising on cultural practices to prevent pest incidence, and identifying common pests at various crop growth stages through symptom-based decision rules. By integrating multiple modules, the system enhances decision-making for improved barley production.

Tomato Expert System: Tomato Crop Expert Information and Advisory System developed Babu et al. (2010) a web-based in India to support tomato growers in identifying and managing major pests and diseases. The system was developed through a collaborative effort involving agricultural scientists, tomato crop experts, and a team of computer engineers and programmers. This expert system consists of two major components: a **Tomato Information System** and an **Online Advisory Expert System**. The information module provides users with static knowledge on tomato varieties, common diseases including viral infections, pests affecting tomato plants and fruits, their symptoms, preventive measures, and recommended chemical controls. The advisory module enables interactive diagnosis, where the user answers a series of questions posed by the system. Based on the responses, the expert system identifies the specific pest or disease problem and suggests suitable control measures. Thus, this expert system serves as an effective decision-support tool for improving tomato crop management and productivity.

e-Sagu is an IT-based personalized agro-advisory system designed to support farmers with timely and farm-specific expert guidance. The term “Sagu” means cultivation in the Telugu language. The main objective of e-Sagu is to enhance agricultural productivity by providing high-quality, customized advice directly to farmers at their doorstep, even without the farmer having to raise a query. The system integrates modern information technologies such as databases, internet services, and digital photography to strengthen and improve the effectiveness of agricultural extension services. e-Sagu was successfully implemented in 2004, delivering advisory support to 1,051 cotton farms across three villages in the Warangal district of Andhra Pradesh.

5. SOME INTERNATIONAL AGRICULTURAL EXPERT SYSTEMS

Soybean Disease Diagnosis Expert System: Soybean Disease Diagnosis Expert System, created by **Michalski *et al.* in 1983**. This expert system was designed to diagnose diseases affecting soybean crops and is considered a landmark application of artificial intelligence in agriculture. A unique feature of this system was its use of two different types of decision rules: (1) rules representing the diagnostic knowledge of human experts, and (2) rules generated through inductive learning based on several hundred real disease cases. This combination of expert knowledge and machine learning made the system highly effective in agricultural disease diagnosis.

POMME: This expert system developed by **Roach *et al.*, 1985** for apple orchard management. This system was designed to support apple growers by advising them on when and what type of pesticide sprays should be applied to prevent pest infestations. In addition to spray recommendations, POMME also provided guidance on managing various orchard problems such as treatment of winter injuries, drought control, and multiple insect pest issues. The system is considered an early example of applying expert system technology in horticultural crop management.

BESTCOMP: Jayawardhana *et al.* (2003) developed a user-friendly expert system named BESTCOMP (Expert System for Sri Lankan Solid Waste Composting) to support local authorities in achieving better management of solid waste composting in Sri Lanka. The BESTCOMP expert system mainly focused on understanding and guiding the physical, chemical, and biological processes involved in composting. This system served as a decision-support tool for improving composting practices and effective solid waste management.

Expert System Study by Kurata *et al.* (1989): described the development and application of expert systems designed to support farmers in areas such as tomato cultivation, farm machinery troubleshooting, and farm work scheduling. The tomato growing Expert System answers questions on greenhouse environment, disease and fertilization. The farm machinery program collects information about problems in machinery operation and provides a scheduling system for sending a technician to the farm, depending on the diagnosis. The work scheduling Expert System consists of long, middle and short term scheduling programs for field operations. The number of working days for each farm, progress of operations, materials to use and requirements for a specific day's operation are some of the questions answered.

Morgan *et al.* (1989) described on Expert System for crop variety selection. They developed a system which was designed to consider the soil characteristics, water availability and prevalence of diseases. This system was developed for winter wheat in Scotland. This would allow agricultural extension officers to recommend varieties with confidence thereby reducing the demand for advice from specialist crop advisors.

Hybrid Expert System: The hybrid Expert System approach developed by Elango *et al.* (1992, employed to provide managerial assistance under water shortage situations. It is combined with an irrigation game model CASIMBOL (Computer Aided Simulation of Irrigation Management Below Outlet) for managing water deficits.

6. MOBILE BASED EXPERT SYSTEM

- Crop insurance mobile app by Ministry of Agriculture, GoI.
- IFFICO kissan app
- Agrimarket mobile app
- mKissan app
- RainbowAgri app
- Manditrades app
- Mpower social app
- eSAP app....etc
- Kisan Suvidha App
- Pusa Krishi App
- Soil Health Card App
- PM-Kisan App
- eNAM App
- Plantix App
- AgriApp
- Krishi Network App
- Digital Green App
- Gramophone App
- Meghdoot App
- Crop Doctor App
- Kheti Badi App
- FarmRise App (by Bayer)
- RiceXpert App
- CABI Plantwise App
- Weather-based Agro Advisory App
- SmartAgri App
- AgroStar App
- Fasal Salah App

7. ADVANTAGES OF AGRICULTURAL EXPERT SYSTEM

- ✓ Expert systems provide expert-level knowledge to users whenever required, especially where specialists are not available.
- ✓ They give quick solutions and recommendations for complex problems.
- ✓ Expert systems provide uniform and reliable advice without variation.
- ✓ They are useful for farmers in rural and remote regions where expert services are limited.
- ✓ Expert systems help in early identification of pests, diseases, and nutrient deficiencies.
- ✓ They assist in proper use of inputs like fertilizers, pesticides, irrigation water, and labor.
- ✓ Expert knowledge is stored permanently and can be reused even when human experts are unavailable.
- ✓ They help users learn by explaining the reasoning behind recommendations.
- ✓ Once developed, they can provide guidance to many users at low cost.
- ✓ Expert systems help increase crop yield, reduce losses, and improve farm profitability.

8. LIMITATIONS OF EXPERT SYSTEM

- Many farmers in the country are illiterate and knowledge of computers in rural areas is still unreached, which restricts the effective use of expert systems.
- Expert systems need continuous expansion and updating to include newly emerging pests, diseases, and crop ailments in local conditions.
- There is a requirement to incorporate advanced disease diagnostic techniques such as laboratory tests, soil test reports, tissue tests, and plant analysis reports for more accurate recommendations.
- Integration of nutrient deficiency modules with the existing knowledge base is necessary to provide comprehensive crop advisory services.
- Poor quality images used in expert systems may create confusion in diagnosis, leading to incorrect decision-making. Therefore, high-quality visual support must be ensured.
- Managing a large knowledge base becomes complex, as writing and sequencing a large number of rules is difficult.
- Verification and validation of extensive rule-based systems is also challenging.
- Computers lack common sense, and therefore expert systems must be developed carefully. Even minor programming errors may lead to system failure.
- Many farmers are not proficient in English, so expert systems should also be developed in regional and local languages.
- Expert systems must be demonstrated at village levels through block or local administrative units so that farmers can gain familiarity and build confidence in using them.
- Expert systems cannot provide creative or innovative responses in unusual situations in the way human experts can.
- They often lack flexibility and the ability to adapt to rapidly changing environments and field conditions.
- Expert systems may fail to recognize situations where no appropriate solution exists within the knowledge base.
- Knowledge acquisition remains a major bottleneck in applying expert system technology to new agricultural domains.
- Expert systems are not as compact as neural network or genetic algorithm-based systems, making them harder to embed into other applications.
- At run-time, the inference engine and working memory must remain part of the system, increasing complexity and resource requirements.

9. CONCLUSION

Agricultural expert systems have emerged as effective digital tools for supporting farmers and extension workers in addressing complex crop production and management challenges. By integrating expert knowledge into computerized decision-support platforms, these systems provide accurate recommendations on pest control, disease diagnosis, irrigation scheduling, nutrient management, and crop advisory services. Expert systems hold immense potential in strengthening agricultural extension services, improving farm decision-making, and promoting sustainable agricultural development, especially in countries where expert support is scarce and timely advisory is essential.

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