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# Tobacco Agridaksh: An Online Expert System

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## ABSTRACT

New advances in information technology led to the development of Expert Systems and their application in various sectors including farming. In India, agricultural production has been transformed into a multifaceted business enterprise. Indian agriculture to remain competitive needs the accumulation and integration of scientific knowledge, and information from many diverse sources. Indian farmer often relies on agricultural specialists, advisors and agricultural research and development institutes for agricultural information for better decision making at the actual farm situation. Unfortunately, timely specialist assistance is not available when the farmer needs. Thus the situation demand for a 'virtual expert' who can give personalized expert advice to a large community of farmers, specific to their needs and aspirations considering various knowledge sources. The role of expert systems in tobacco sector and its applications in effective production and protection technologies have been discussed in this article. It is almost impossible for any human expert to consider every piece of available information before arriving at optimal decisions. To overcome this problem and provide precise information to the farmers, "expert systems" have been developed with a primary goal to make expertise available to clients and decision makers who need answers swiftly. The main aim is to deliver the required information and disseminate the up-to-date scientific knowledge in a readily accessible and easily understood form to the farmers. It is one of the most efficient extension tools to take the technology from scientists to the growers directly without any distortion of content which normally creeps in because of multiple agencies involved in conventional technology transfer systems. With this aim, ICAR-Central Tobacco Research Institute has developed a web-based expert system on tobacco using "Agridaksh"- an online tool developed by ICAR-Indian Agricultural Statistics Research Institute. This, online expert systems has the tremendous capacity to transfer location specific technologies and advice to the farmers with a greater precision.

**Keywords:** Agridaksh, Expert System, Software, Knowledge, Web

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## INTRODUCTION

Expert systems also known as Knowledge Based Systems (KBS), are computer programs developed for simulating problem-solving behavior of an expert in a narrow domain (Jackson 1999; Donald 2004; Durkin 1994; Weis and Kulikowasaki 1984; Patterson 2004). They combine the experimental knowledge and experience with intuitive reasoning skills of specialists to aid end users (farmers) in making the best decisions to secure solution for their problems. The expert systems have tremendous potential in modern agriculture. Agricultural Expert System (Prasad and Vinaya Babu 2006; Gillard 1998; Richard and Nicholas 1991) is a Decision Support System (DSS) that helps the agricultural extension agents, who have to identify the problem and advice the farmers to take action, based on the observations from the fields or from the expert systems.

In India, utility and importance of expert systems are well recognized along with the emerging trends in agriculture and as a result, expert systems have made their presence felt in several facets of Indian Agriculture. In agriculture, expert systems combine the accumulated expertise of individual scientific disciplines, e.g. Plant Pathology, Entomology, Agronomy, Agricultural Meteorology, etc., (Ravisankar *et al.* 2010 & 2009; Edwards *et al.* 1993; Gerevini *et al.* 1992; Jones and Roydhouse 1995; Nathan and James 1997) into a framework that best addresses the precise and location specific needs of farmers.

The applications of expert system in agriculture are rapidly growing. Such applications are very effective in situations when the domain expert is not readily available. At present, most of the institutes under Indian Council of Agricultural Research (ICAR) developed several expert systems for various purposes, which are available in areas including crop production, disease and pest management, farming system research, poultry management, animal husbandry, etc. These systems have extensive use in the areas of fertilizer application, diagnosis of diseases, crop protection, farm

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advisory, irrigation schedule, and post-harvest technology. On-line expert systems are developed on various aspects of Medicinal Plants (Srinivasa Rao *et al.* 2015, 2014), Coconut (Ani Dath and Balakrishnan 2016), Maize (Yadav *et al.* 2012), Tomato (Prasad Babu *et al.* 2010), Cotton (Wang and Lu 2008), Wheat (Islam *et al.* 2012), Potato (Wharton *et al.* 2008), Tobacco (Ravisankar *et al.* 2014a & 2014b) etc. for storing and disseminating location specific information. Using Agridaksh tool, web-based expert systems for Maize, Tomato, Mushroom and Tobacco have been developed and hosted in ICAR-IASRI web server for online accessing (http://agridaksh.iasri.res.in/). The Web technologies allowed the knowledge engineers and domain experts to build the expert systems that were having dynamic knowledge base capabilities (Marwaha *et al.* 2002). The domain experts can update the knowledge at the central server and the users can access to the recent knowledge base through a Web interface. Ontology is the state-of-the-art knowledge representation technique that allows the domain experts to code their knowledge in a particular domain. They have the capacity/scope to be used in a distributed environment like Internet and provide the dynamic and reusable capability to the knowledge base.

## MATERIALS AND METHODS

As a first step for building the expert system, domain experts of the tobacco were consulted for the list of attributes for building the knowledge model on tobacco varieties, insect pests and diseases. After preparing the trait list, the required knowledge was captured as per the activity chart developed by the domain experts. Using this knowledge base, a web-based expert system on tobacco was developed using a tool "Agridaksh" (2014-2019) in N-tier architecture in the form of static web pages and ontology-based system (Fig. 1).

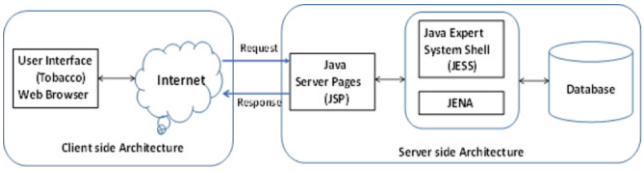


**Fig. 1:** N-tier architecture of the system

The N-tier architecture composed of two components viz., Client-side Architecture consisting of web browser and Internet connectivity and Server-side architecture with application logic level Java Server Pages (JSP), Java Expert System Shell (JESS) inference engine, Semantic Web framework JENA and database. The last layer in this structure is the database layer consisting of tobacco information. Java Server Pages (JSP) with Hyper Text Markup Language (HTML) documents interleaved with Java are used as a technology to create dynamic content on the Web. The application logic is spread over a Web Server and an Application Server. In case, the request is for an application, it will forward the request onto the Application Server. The Web Server handles request from clients and generate response through static HTML document. To retrieve required information from the system, whenever the user selects that option using web browser, that request will be received by JSP in web server through internet and generate a response to the client in the form a table as a simple HTML document.

The expert system developed is in the form of static web pages using hypertext mark-up language (HTML) and ontology-based system using a Web Ontology Language (OWL). For ontology-based retrieval of the information on tobacco from database, JESS inference engine and Semantic Web framework JENA were employed in the system. JESS is an expert system shell and scripting language and it supports the development of rule-based expert systems which can be firmly coupled to code written in the robust, portable Java language. JENA is a Java framework for building Semantic Web applications. It provides a programmatic environment for Resource Description Framework (RDF), RDFs and Web Ontology Language (OWL), including a rule-based inference engine. Protégé (Noy *et al.* 2001) a language that belongs to OWL (Smith *et al.* 2004) was used to write ontology-based selection module. At its core, Protégé implements a rich set of knowledge-modeling structures and actions that buttress the creation, visualization, and manipulation of ontologies in various presentation formats. Protégé was customized to provide domain-friendly support for creating knowledge model on tobacco and entering data. After developing knowledge model, values of attributes have been entered in the system through the knowledge access module and stored in text format as well as in decision tree format. The posted knowledge was validated and the expert system was tested for any possible errors or shortcomings. JESS was used to make inter relations with one query to the other with the stored database until a result is displayed.

### About Agridaksh

Agridaksh, a tool for building online expert system for various crops has been developed by ICAR-Indian Agricultural Statistics Research Institute, New Delhi. (Marwaha, 2012). It has modules on Knowledge Model Creation, Knowledge Acquisition, Problem Identification and Knowledge Retrieval. The knowledge acquisition module has data entry forms for insertion, updating and deletion of new basic, specific features for variety management, diseases and insect pests. The knowledge retrieval module gives detail information about varieties by state wise as well as district wise with each variety having basic and specific features. The plant protection module has provision for insertion, updating and deletion of specific features of new diseases, insect pests, physiological disorders, nematodes and weeds. It also generates various general reports about detail information on insect pests, diseases, nematodes, weeds, physiological disorders, pesticides, nutrients and many more.

The knowledge processing module has Rule based Problem Identification and Ontology based Problem Identification sub modules. In Rule based Problem Identification, the users enter into the question answering mode and selects one of the multiple options provided in the page. Here, all the options are given in the text format. The question answer session yields in reaching the solution for the problem such as disease diagnosis or identification of pests. In Ontology based Problem Identification, the users enter into the question answer session, but here the text is supported along with the pictures. Presently, it can answer the disease and pest identification as well as varietal selection.

### Tobacco Agridaksh

Tobacco Agridaksh is a user-friendly software consists of three main modules viz., Variety selection, Disease diagnosis and Insect Identification. The Variety Selection module

displays location specific varieties with area of adaptation and average yield. Disease Diagnosis and Insect Pest Identification module helps to diagnose the diseases and to identify insect pests affecting the tobacco crop and suggest preventive and control measures. Home page of the software contains, detail information about Institute, Origin of the crop, Tobacco varieties, Production technology, Nursery management, Package of practices, and Success stories.

For building the expert system of tobacco, the knowledge was captured as per the activity chart from the domain experts. The knowledge was saved in text format as well as in decision tree format. The captured/collected knowledge was validated after entering it in the system. The expert system was then tested for any possible errors or shortcomings.

## RESULTS AND DISCUSSION

The software consists of three main modules viz., Identification of Insect Pests, Diseases and Varietal Selection. The procedure for executing the three modules is given below.

### Insect Pest Diagnosis

To identify a particular insect pest through ontology-based inference system, the user has to select the 'Problem Identification' option from the tobacco agridaksh home page followed by 'Language (English)' and select module options viz., 'Pest identification, Disease Diagnosis and Variety selection' (Fig. 2). In the 'Pest identification', the system will prompt to 'select the crop' viz., Maize, Tobacco and Indian mustard options as expert question. After selecting the tobacco crop, the system will display the expert question as "Select the stage of the crop" i.e., Nursery or Field. After selecting one of the stages, again the system prompts to "Select the part affected" i.e., leaf or stem. When the user selects one of the options, the system will display the expert question as "Select the initial nature of damage". In this option, all the symptoms caused by pest with photos will get displayed. The user has to select one of the symptoms which will match his requirement and followed by 'Proceed further'. A fresh menu with page titles as "Problem identification – Pest identification" gets displayed which consisting of two sections namely "Question-Answer History" and "Expert solution". The 'question-answer history' displays a table


**Fig. 2:** Flowchart for identification of insect pest

**Fig. 3:** Ontology based retrieval: Identification of tobacco insect pest

consists of 'Expert question' and 'Your response' that illustrates, the sequence of questions selected and response given by the system. The 'Expert solution' option displays list of photos by identifying a particular insect pest (Fig. 3).

### Disease diagnosis

The system has two different methods for disease diagnosis *viz.*, the first method uses rule-based inference (information system) and the second method uses ontology.

***Method 1:*** Knowledge Retrieval (Rule based inference): Knowledge retrieval flow chart of tobacco diseases contains information about 12 tobacco diseases namely angular leaf spot, black shank, brown spot, collar rot, frogeye spot, hollow stalk, orobanche, root-knot, sore shim, damping off, leaf curl virus and tobacco mosaic. For every disease, twelve characters were stored namely pathogen name, pathogen geographical distribution, pathogen life cycle, symptoms, control, prevention, spread mode, primary source, secondary source, disease pathogen, congenial environment and occurrence period. When the user selects a particular disease in crop protection module of tobacco diseases from home page of tobacco agridaksh, all these parameters along with disease image gets displayed. Step-by-step procedure for retrieval of a particular disease can be obtained by given procedure. To get the information about any disease, the user has to select the 'Crop Protection' module followed by 'Tobacco' as crop from

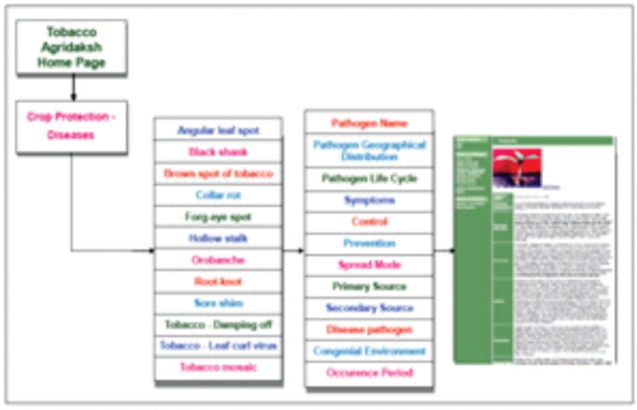


**Fig. 4:** Rule based retrieval: Flowchart for retrieving of tobacco disease

the home page (http://agridaksh.iasri.res.in/tobacco.jsp) of tobacco agridaksh. Once, it is selected, a new menu with title as "Knowledge Retrieval – Plant Protection" gets displayed. The user has to select the 'Disease name' from the drop-down list followed by 'Next' option to display the information with the image of a particular tobacco disease (Fig. 4).

***Method 2:*** Identification of a disease (Ontology based system): To identify a particular disease through ontology-based inference system, the user has to select the 'Problem Identification' option from the tobacco agridaksh home page (http://agridaksh.iasri.res.in/tobacco.jsp) followed by Language (English)' and select module options viz., 'pest identification, disease diagnosis and variety selection'. Proceeding further with 'Disease Diagnosis, the system will prompt 'select the crop' with Maize, Tobacco and Indian mustard options as expert question. After selecting the tobacco crop, the system will display the expert question as "Select the stage of the crop" i.e., Nursery or Field. After selecting one of the stages, again the system prompts as "Select the part affected" i.e., leaf or stem. When the user selects any one of that option, the system will flash the expert question as "Select the initial symptom". In this option, list of symptoms with its photo causing diseases will get displayed. The user has to select one of the symptoms which will match his requirement and followed by 'Proceed further'. A fresh menu with the title page "Problem identification – Disease diagnosis" gets displayed which consists of two sections namely "Question-Answer History" and "Expert solution". The 'question-answer history' displays a table that consists 'Expert question' and 'Your response' that illustrates, the sequence of questions selected and response given by the system. The 'Expert solution' option displays list of photos by identifying a particular disease (Fig. 5).

**Fig. 5:** Ontology based retrieval: Identification of tobacco disease

**Varietal Selection**

To identify a particular variety through ontology-based inference system, the user need to select the 'Problem Identification' option from the tobacco Agridaksh home page (http://agridaksh.iasri.res.in/tobacco.jsp) followed by 'Language (English)' and select module options *viz.*, 'Pest identification, Disease Diagnosis and Variety selection' (Fig. 6). Once the 'Variety selection' option is chosen, the system will prompt 'select the crop' viz., Maize, Tobacco and Indian mustard options as expert question. Once the tobacco crop is chosen, the system will display Question-answer history and expert question, "Select the area of adaptation" viz., Andhra Pradesh, Bihar, Gujarat, Karnataka, Orissa, Tamil Nadu and West Bengal. After selecting the area of adaptation, again the system prompts, "Select the type of tobacco" in terms of 'Flue Cured Virginia' or Non-Flue Cured Virginia' in case of Andhra Pradesh and Karnataka and Non-Flue cured Virginia in other regions along with Question-answer history. When the user selects 'Flue Cured Virginia (FCV)' in Andhra Pradesh, the system asks the expert question as to select the region for FCV i.e., Northern Light Soil (or) Southern Light Soil (or) Traditional Black Soil and Karnataka light soils, the system asks the expert question as Karnataka Light Soils. Then the system displays the list of varieties with their name, average yield and its photo. If the user selects the type of tobacco as "Non-Flue cured Virginia" then the system asks to choose the type of Non-FCV tobacco viz., *Bidi*, Burley, Cheroot, *Natu*, Oriental, chewing, cigar cheroot, cigar wrapper, *hookah* grown in various states. Once the type of non-FCV tobacco grown in a region, is selected, the system will find and display the list of varieties approved for that region with name and average yield with picture (Fig. 7). Restart button available at each step after 'select crop' option enable the user to backtrack to select the module option. To get the list of all varieties, the user has to select 'Tobacco Varieties' option in the home page of tobacco Agridaksh which displays Variety name, Year of release, State, Productivity and Salient traits.

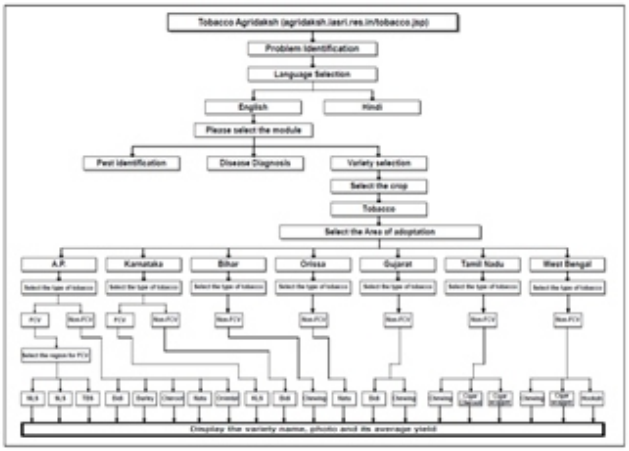


**Fig. 6:** Flow chart for variety identification

**Fig.7:** Ontology based retrieval: Varietal identification

Tobacco Agridaksh system has immense potential to transfer location specific technology and provides valuable advice to the farmers précised manner. The web-based tobacco expert system developed is an integration of image and textual data, which can be used by extension personnel, researchers, development workers and farmers to identify the tobacco varieties, diseases, insect pests and their management. This system can be accessed from any location and easily be executed with user-friendly interface for obtaining the required information. This not only provides global accessing of all the information about Indian tobacco but also greatly useful to enhance decision making capacity of the farmers, agricultural extension personnel, development agencies with regard to crop management and enhancing crop yield. It determines the best strategy for varietal selection, disease diagnosis, insect pest identification, recognizing nutrient deficiencies, weed identification and their management strategies. Owing user-friendly menus, it is easy to execute this system and retrieve the information as per the emerging needs, which will aid in selection of location specific varieties and minimizing the losses due to insect pests and diseases and ultimately lead to improved production and quality of tobacco.

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