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Web based expert system for tobacco disease management

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Abstract
Tobacco quality and production are widely affected by diseases in both nursery and field crop. The yield losses due to diseases can be as high as 50% depending on the type and intensity of disease(s). Primary diseases affecting the tobacco are frog-eye spot, brown spot, black shank, damping-off, wilt, root-knot, mosaic and leaf curl diseases. An accurate and rapid diagnosis can help to take up appropriate and timely corrective measures and thus minimize yield losses. However, the end users are not able to utilize the available information developed by scientists. Symptoms of some diseases may sometimes be similar to nutritional disorders and hence confusing.

Information technology created new vistas of scientific information, social interaction and communication. Based on information technology, Web based expert system on various diseases of tobacco, symptoms and their management was developed and linked to "Agridaksh" managed by IASRI for providing global access. The diseases on tobacco were classified into minor and major in both nursery and field crop and the database was designed in tree structure. The system has two different methods for disease diagnosis. The first method uses rule based inference (information system) and the second method uses ontology. The former is text based while the latter also shows pictures with the text. In both the approaches the user enters into the question-answer session with the system and at the end of the session, a particular tobacco disease is identified and its images get displayed online. Under this system, a knowledge model has been created in such a way that includes a knowledge acquisition, ontology based problem identification and a knowledge retrieval system for tobacco diseases. This system is useful to enhance the capacity of farmers, agricultural extension personnel and tobacco crop development agencies for tobacco disease management to increase crop yield. The expert system developed is of great utility as it brings disease symptoms and damage on tobacco and their management to a single platform.

Keywords: Disease, Knowledge, System, Management, Ontology, Tobacco

Introduction
Tobacco production and quality are widely affected by fungal, viral and nematode diseases in both nursery and field crop. The yield losses ranging between 21-53% from various diseases have been documented [1]. Important diseases affecting the tobacco are Frogeye spot, Brown spot, Black shank, Damping-off, Wilt, Root-knot, Mosaic and Leaf curl diseases. Plant protection involves the correct and timely identification of these diseases and their control. The identification of diseases is the difficult task and often requires consultation with specialists. An accurate and rapid diagnosis can avoid losses by taking appropriate management practices. Scientists have developed various management practices for many diseases of tobacco, detailed digital photographs of symptoms are made available and precautionary measures are established.

However the end users have not been able to utilize the information for want of easy access and ineffective extension mechanism. Manifestation of disease symptoms on leaf may generally mislead in the process of disease identification. Symptoms of some diseases like wilt, black shank, and anthracnose stem infection, some viral diseases are often confusing requiring expert opinion. Enhancement of information technology created new vistas of scientific information, social interaction, communication and learning leading to the automated systems and information delivery in order to handle the hard core tasks like management of tobacco diseases in the present context.

Various expert systems were developed in agriculture to the diseases in different crops [2]. Prasad *et al*. (2006) formulated an expert system viz., AMRAPALIKA [3] for diagnosing 14 different pests including eight diseases and six insects in Indian mango variety. Vinod *et al*. (2008) developed an image based rapeseed-mustard disease expert system [4] 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. Sarma *et al*. (2010) developed an expert system in order to diagnose and manage the diseases occurring in rice crop [5]. A web based tomato crop expert information system was developed by Babu *et al*. [6] which provides information on pests of tomato fruits and plants, their symptoms, preventions and chemical controls. National Institute of Agricultural Extension Management (MANAGE) has developed an expert system to diagnose pests and diseases and some deficiency problems limiting rice yield in rice crop and suggest preventive/curative measures. Expert System on Wheat Crop Management [7] was developed to solve the problems on pest and diseases on wheat crop faced by a farmer at remote places where the services of the expert is not always available.

Expert system combines experimental knowledge and experience with intuitive reasoning skills of specialist's to aid farmers in making best decision for their crops [8-10]. The web technologies allowed the knowledge engineers and domain experts to build the expert systems that were having dynamic knowledge base capabilities [11]. In the present study, a web based expert system with image based tobacco disease identification and management was developed which enables the extension personnel, researchers and farmers in identification and management of many tobacco diseases.

Materials and Methods

As a first step for building the expert system, domain experts of the crop (pathologist) must agree to a list of attributes for building the knowledge model on tobacco diseases. After preparing the attribute list, the required knowledge was captured as per the activity chart developed by the domain experts. The information collected for designing the knowledge base was mainly classified into 4 categories, *viz*. Nursery-Leaf, Nursery-Stem, Field-Leaf, Field-Stem and the 'crop name' was selected as a primary key. The attributes included in the system are Crop name, Disease name & its image, Pathogen name, Pathogen geographical distribution, Pathogen life cycle, Symptoms, Control, Prevention, Spread mode, Primary source, Secondary source, Disease pathogen congenial environment and Occurrence period. These fields were created with text boxes for data entry / modification and label boxes for the title of the text. The user can embed an image of disease symptoms and crop photos in the knowledge base itself. Using this knowledge base, a web based tobacco varieties expert system was developed using a tool Agridaksh [12] in an N-tier architecture in the form of static web pages using hypertext mark-up language (HTML) and ontology based system using a Web Ontology Language (OWL) for providing global accessing of the required information on tobacco diseases (Fig.1).

It is a N-tier architecture which consists of various components viz., the client layer, the application logic level (JSP), the Semantic Web framework JENA, JESS inference engine and the database layer which consists of tobacco disease information. Java Server Pages (JSPs) with HTML documents interleaved with Java are used as a technology to create dynamic content on the Web. The Web Server handles request from Web Clients and generate response through static HTML document. To retrieve the information for a particular disease from the system, whenever the user click 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 simple HTML document.

Protégé [13, 14], a Web Ontology Language (OWL) is used for ontology based application which is free, open-source platform that provides a growing user community with a suite of tools to construct domain models and knowledge-based applications. Protégé was customized to provide domain-friendly support for creating knowledge model on tobacco diseases and entering data. After developing knowledge model, values of attributes for each disease of tobacco has been entered in the system through the knowledge acquisition module and stored in text format as well as in decision tree format. The entered 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 particular variety is selected. The system thus developed has the capability to store and manage extensive information on tobacco diseases. The system assists the client to use ontology based inference for varietal identification based on the stored knowledge.

Results and Discussion

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 (Fig. 2) contains information about 12 tobacco diseases namely Angular leaf spot, Black shank, Brown spot, Collar rot, Frog eye spot, Hollow stalk, Orobanche, Root-knot, Sore shim, Damping off, Leaf curl virus and Tobacco mosaic. For each disease, 12 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. Whenever the user selects a particular disease in crop protection module of tobacco diseases from home page of tobcco 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 retrieve the information about a particular disease, the user has to select the 'Crop Protection' module followed by 'Tobacco' as crop from the home page (http://agridaksh.iasri.res.in/tobacco.jsp) of tobacco agridaksh (Fig. 3). 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 (Fig. 4) followed by 'Next' option to display the information with the image of a particular tobacco disease (Fig. 5). Information about some of the important diseases are given below.

Frog-eye spot caused by *Cercosporanicotianae*- a minor disease in both nursery and field crop, reducing the yield and quality of leaf. Humid and warm weather conditions during August and September are highly congenial for development of the disease. Small spots appears first on lower leaves and spread to upper leaves. In several cases spots coalesce to become bigger spots leading to drying up of leaves. Losses due to frog-eye spot have been estimated to the tune of 23% in FCV tobacco [15] and 21% in *bidi* tobacco.

Anthracnose caused by *Colletotrichumtabacum*a serious problem in nursery and early stages of field crop – results in heavy losses. Brown spot disease caused by

Alternariaalternata– a minor disease affecting both nursery and field. During humid and atmospheric temperatures of 20 – 25 ºC, brown spot appears on lower leaves and spreads faster to upper leaves. It causes losses in yield (up to 40%) and greatly reduces quality of tobacco [16].

Damping-off caused by *Pythiumaphanidermatum*– A widespread and destructive disease in nurseries. Conspicuous symptoms of this disease are the sudden death of seedlings in patches leading to the uneven stand. The extent of loss in nursery is estimated to the tune of 61.2% [17].

Leaf blight/Black shank disease caused by *Phytophthoraparasitica*, var. n*icotianae*– a major disease both in nursery as well as in field. Under severe cases, losses up to 50% have been reported. Wilt disease caused by *Fusariumoxysporum*– a minor disease in field. Conspicuous symptoms of disease are slow yellowing, partial wilting and drying of leaves on one side of the plant and drowning of leaves on the effected sides.

Tobacco mosaic (TMV) and leaf curl are major viral diseases in field crop. TMV is a contagious disease. Plants infected in early stages show stunted growth reducing the yield and quality of leaf. Leaf curl disease is transmitted through whitefly, in severe cases, the leaves and stem curls and leaves become thick, shrinkled and many times become unfit for curing.

Root-knot – a minor disease in nursery and field – caused by nematodes and prevalent in most of the light soil nurseries as well as in field crops. Characteristic symptoms of root -knot disease are yellowing of leaves, stunted growth, wilting of plants there by reducing the yield and quality. The yield losses due to nematodes in FCV tobacco are estimated to the tune of 59.4% and 52.9% respectively in nursery and field whereas in *bidi* tobacco it varied from 31 to 51% in field crop.

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' (Fig. 6). 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 stage, again the system prompts as "Select the part affected" i.e., leaf or stem. If the user selects any one of that option, the system will display the expert question as "Select the initial symptom". In this option, list of symptoms with its photo causing diseases will gets displayed. The user has to select one of the symptom which will match his requirement and followed by 'Proceed further'. A new menu with title page as "Problem identification – Disease diagnosis" gets displayed (Fig. 7) which consists of two sections namely "Question-Answer History" and "Expert solution". The 'question-answer history' displays a table consists of 'Expert question' and 'Your response' that describes, the sequence of questions selected and response given by the system. The 'Expert solution' option displays list of photos by identifying a particular disease.

Web based expert systems were developed for disseminating knowledge on diseases of various crops viz., Mustard [4], Tomato [6], Cocount [18], Cotton [19], Potato [20], Maize [21] etc. Stand alone expert systems developed at ICAR-Central Tobacco Research Institute are helping in the storing, retrieval and dissemination of the information on various aspects of tobacco cultivation [22-25]. Web based identification of diseases in tobacco is the first of its kind and followed the methods as required for the control of the identified diseases.

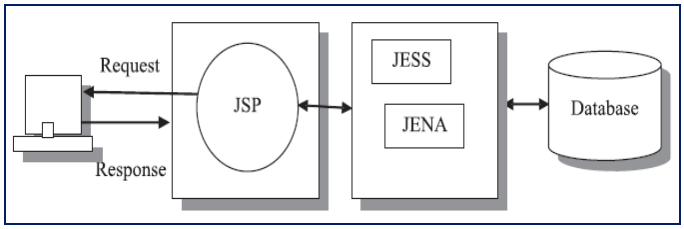

Fig 1: N-Tier Architecture

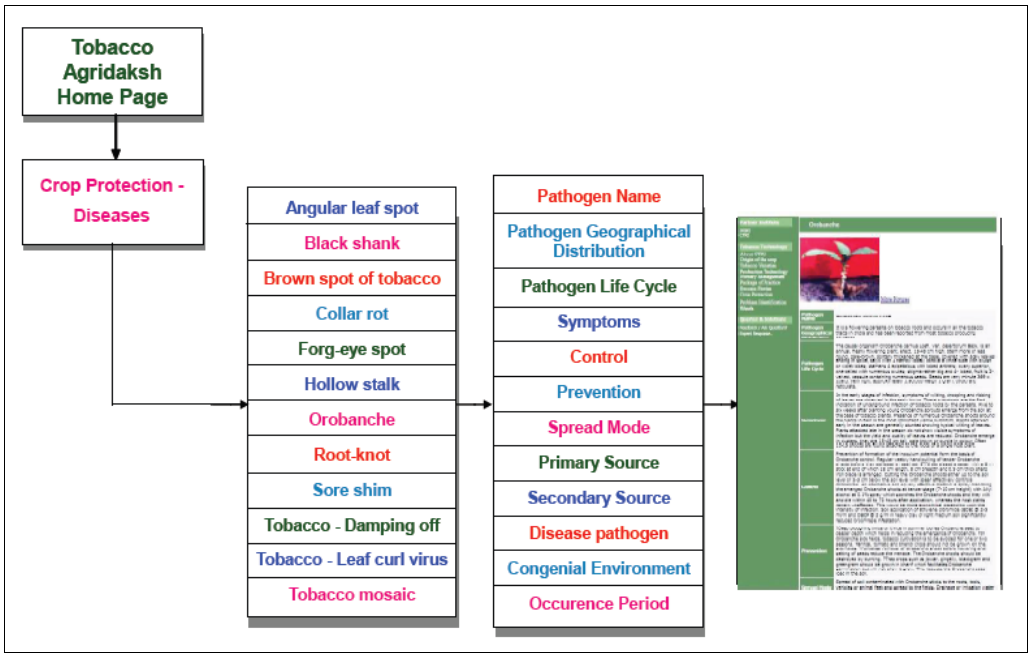

Fig 2: Knowledge retrieval model flow chart

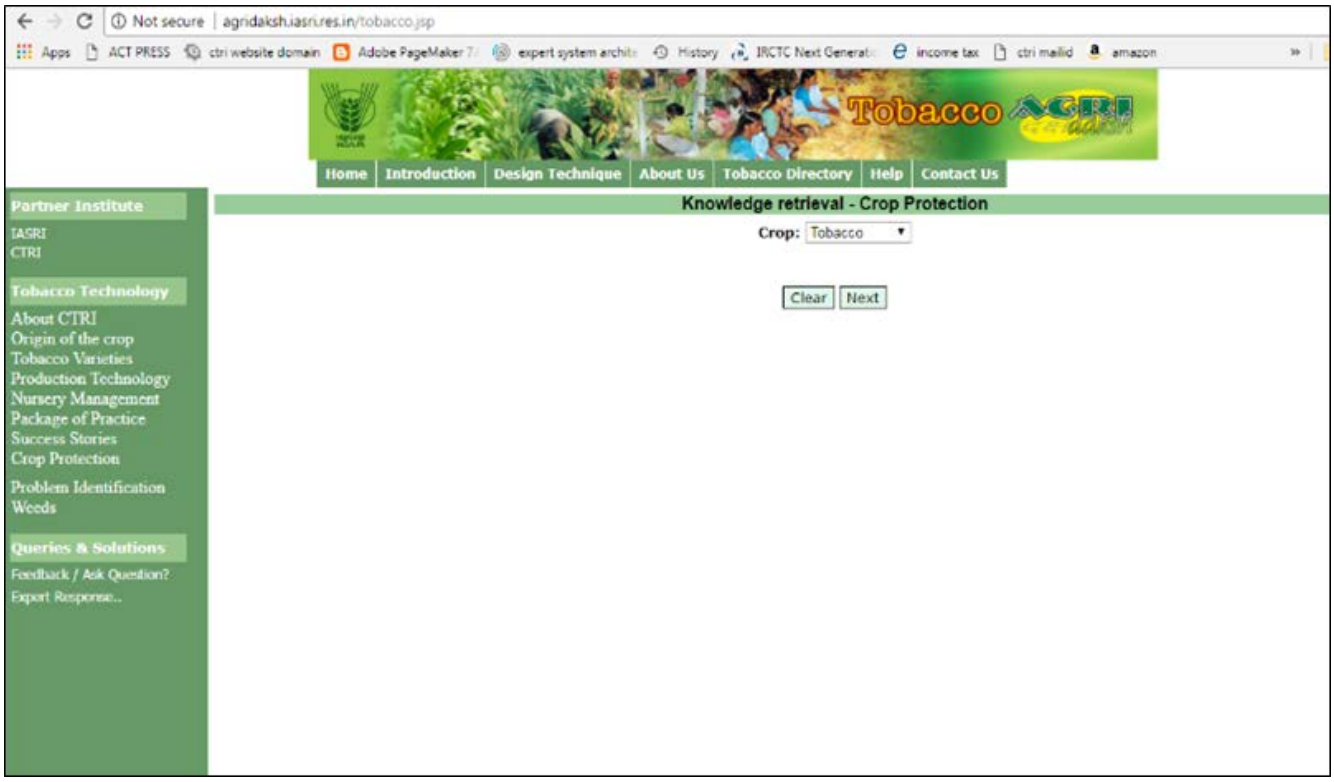

Fig 3: Knowledge retrieval: Selecting crop protection module from home page

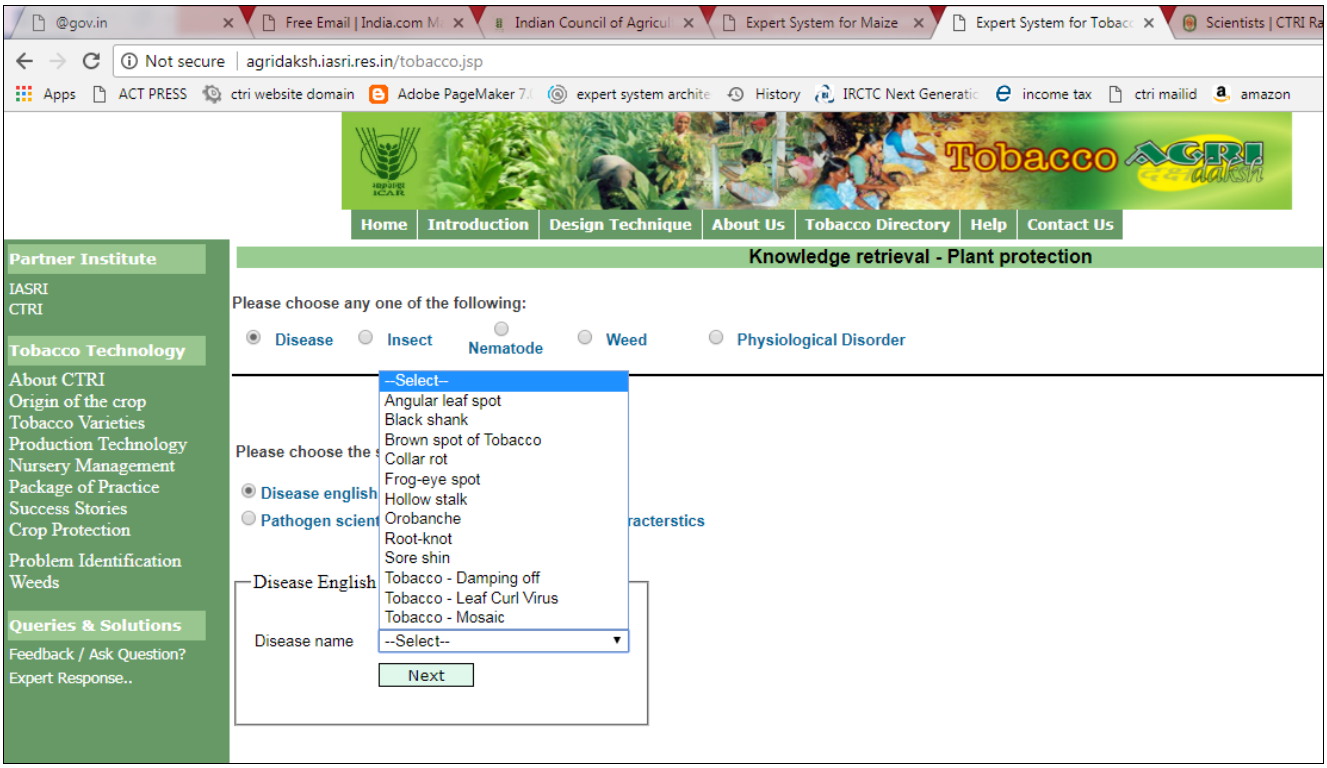

Fig 4: Knowledge retrieval: Selecting disease name from the list

Fig 5: Knowledge retrieval: Orobanche disease information

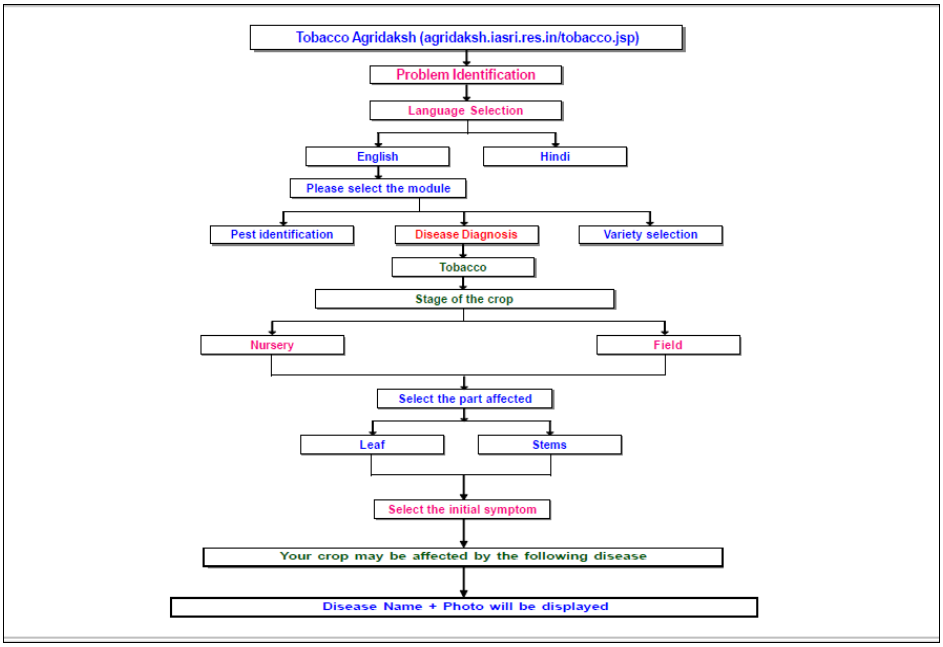

Fig 6: Flow chart for ontology based model

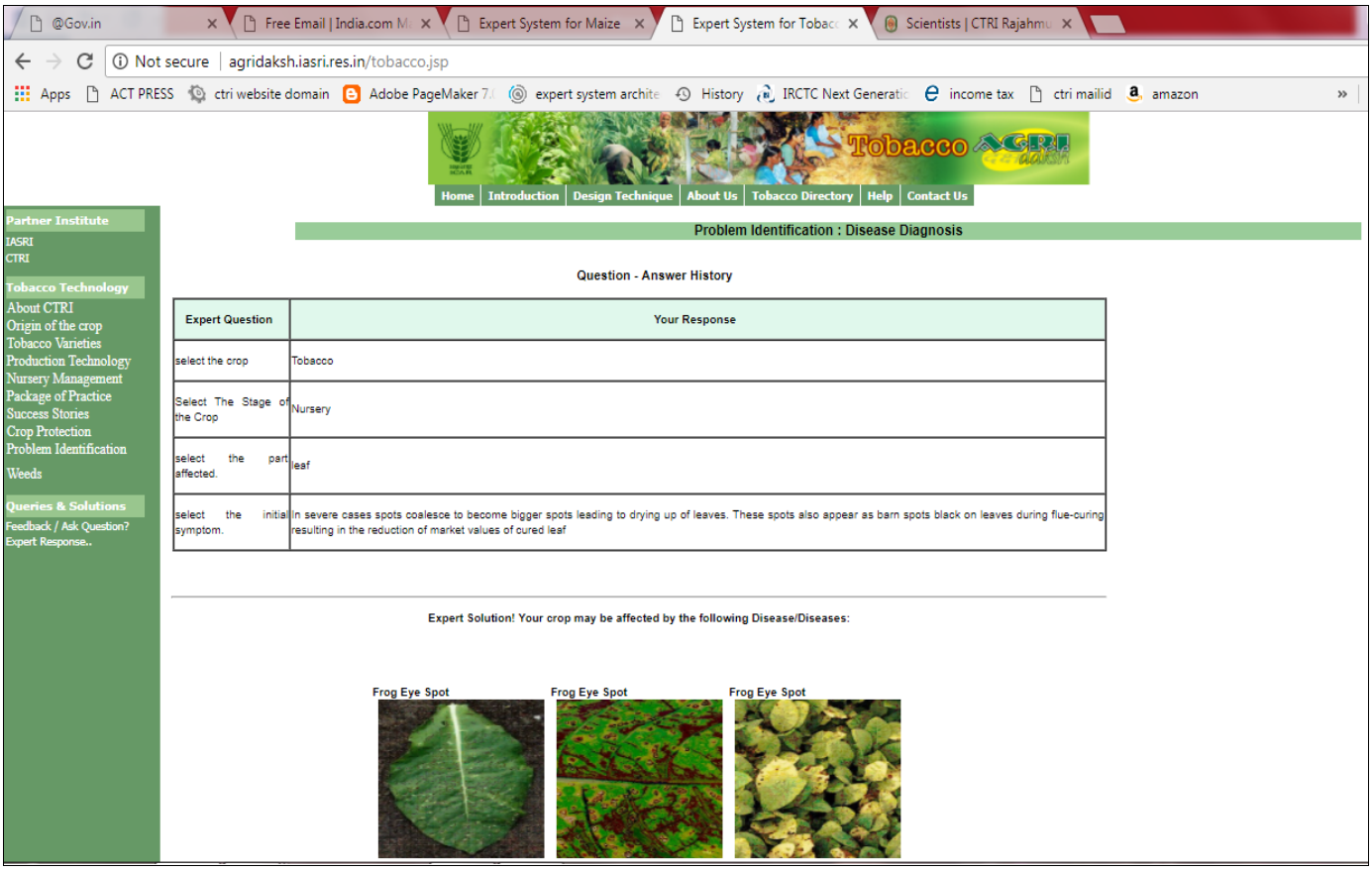

Fig 7: Ontology based model: Identification of a disease

Conclusion

The web based tobacco disease expert system developed is an integration of image and textual data. The system can be used by extension personnel, researchers and farmers to identify the diseases and their management. User can easily identify the disease on the bases of photos of symptoms and text description of diseases. This expert system developed for tobacco can be used in any location. The system enables the viewer to match his problem with different symptoms displayed and identify problems as well as remedial measures. The present expert system developed is of great use that brings damage caused to tobacco by diseases and their management practices to single stage. Anyone who has basic knowledge of computer operation can easily identify the disease from the information given by the farmer and can give corrective measures instantaneously. With user-friendly menus, it is easy to execute this system and retrieve information as per the requirements and take the hard copy of the same.

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