Expert system for identification of natural enemies of tobacco pests

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Abstract

Insect pests are one of the important constraints in production and storage of quality tobacco. Identification of insect pests and their natural enemies (biocontrol agents) is one of the important aspects in integrated pest management (IPM). Identification of natural enemies of tobacco insect pests involves recognition and the stage at which the natural enemies attack the pest. Based on this, an expert system was developed for identification of natural enemies and disease symptoms caused by entomopathogens on tobacco insect pests. Using this system, user can access information available on the natural enemies, their potential in controlling a specific pest and impact of pesticides on the natural enemies. This system provides information on biocontrol agents of tobacco insect pests and their use at proper stage of the pests to scientists, extension workers involved in agriculture development, farmers and students. Using this system one can identify the major insect pests and their biocontrol agents for effective decision making in insect pest management in tobacco and to adopt good agricultural practices. It will help the clientele in decision making to integrate biocontrol agents in IPM of tobacco.

Keywords: Insect pests, tobacco, expert system, biocontrol agents

Introduction

India has a large and diverse agricultural sector with an arable land area of 159.7 million hectares. Current agricultural practices are neither economically nor environmentally sustainable and India's yields for many agricultural commodities are low. Depleting resources, increased use of external inputs, biotic and abiotic stresses in the changing climatic scenario are among the factors responsible. About 2-30 % losses (Chari, 1987) are reported due to insect pests in tobacco in India.

Sole dependence on chemical control is neither economical nor sustainable partly because of rising costs and mainly in view of the resultant adverse effects *viz.,* development of resistance in insect pests, pest resurgence, pesticide pollution and undesirable pesticide residues in tobacco leaves. Biocontrol is an approach to reduce the residue and ancillary problems associated with pesticides application. Biological control refers to management and regulation of natural biotic forces to suppress insect pest population to a level below the economic injury. Nearly 75 natural enemies including parasites, predators and hyper parasites of important tobacco pests were identified and documented (Sitaramaiah *et al.,* 2001).

In order to remain competitive in agricultural sector, the farmer often relies on agricultural specialists and advisors to provide information for decision making. Unfortunately, specialist assistance is not always available when the farmer needs. In order to overcome this problem, "expert systems" have been developed. The primary goal of expert systems research is to make expertise available to decision makers and technicians who need answers quickly. "Expert Systems" is one of the important application oriented branches of artificial intelligence (Russell and Norvig, 2002).

Expert systems (Donald and Waterman, 2004; Patterson, 2004) also called knowledge based systems (KBS), are computer programs developed for simulating problem-solving behavior of an expert in a narrow domain or discipline. In agriculture, expert systems unite the accumulated expertise of individual scientific disciplines, e.g. Plant Pathology, Entomology, Agronomy, Agricultural meteorology, etc., (Denis and Bjarne, 2002; Chakrabarti and Chakraborty, 2007; Ravisankar *et al.,* 2009, 2010; Ahmed Rafea, 2010) into a framework that best addresses the specific, onsite needs of farmers. Expert systems combine the experimental knowledge and experience with intuitive reasoning skills of specialists to aid farmers in making the best decisions for their crops. Thus, they have tremendous potential in modern agriculture.

Agricultural expert system is a decision support system that helps the agricultural extension agents, who have to identify the problem and advise the farmers to take necessary action, based on the observations from the fields or from the expert systems (Prasad and Vinaya Babu, 2006; Chakraborty and Chakrabarti, 2008). It is one of the most efficient extension tools to take the technology from scientists to the farmers directly without any dilution of content, which normally creeps in because of the number of agencies involved in normal technology transfer systems.

Today, in most of the developed countries complex medical, mechanical design and agricultural extension problems are being solved by expert systems (Kostas and Emanuel, 2000; Satvika Khanna *et al.*, 2010). In highly developed countries like Australia and United Kingdom, expert systems in agriculture are freely accessible to individual farmers at their farm offices, where they can get subject matter expert opinion on specific problems in the field by hooking to their agricultural network, which is in turn connected with all the agricultural universities and research stations. In the present study, a rule based expert system (Ajith Abraham, 2005) was developed for identification of natural enemies and disease symptoms caused by different pathogens of tobacco pests which will be a ready reckoner for scientist, extension workers to integrate in IPM.

Materials and methods

The expert system was developed using Visual Basic. Net (Gaddis *et al.*, 2003; Balena, 2005) as front-end application and Oracle (Deshpande, 2004) as back-end application with user-friendly menus. The development of an expert system requires the combined efforts of specialists from specific fields of agriculture and can only be accomplished with the cooperation of growers and extension workers who will use them. The first step in building an expert system is knowledge acquisition (Spangler *et al.*, 2003).

Knowledge on the biocontrol agents was gathered from the experts including scientists, extension workers and other sources (Fig 1). For this expert system, the domain expert is the "Agricultural Scientist - Entomologist". The knowledge engineer codes the knowledge in the form of rules or some other representation scheme. Software experts (System editor) serve as intermediary between the agricultural scientists and the computer that will emulate their expertise. The software expert acquires the knowledge of the crop in the form of facts and rules through interviews and documents analysis and then prepares a knowledge base for the system. The process is repeated until a sufficient body of knowledge has been collected to solve a large class of problems for a crop. A prototype of the expert system was built and presented to the field experts' session using a data / graphic project on system. The expert reviews the acquired knowledge and their comments are documented and the prototype updated.

Knowledge base for various biocontrol agents was created in the form of decision trees (Fig 2) where major insect pests of tobacco *viz.*, *Spodoptera litura, Helicoverpa armigera, Scrobipalpa heliopa, Bemisia tabaci, Myzus nicotianae* and *Lasioderma serricorne* acts as a root. 'Spodoptera' consists of two sub-options *viz.,* 'Litura' and 'Exigua'. 'Helicoverpa' consists of 'Armigera' and 'Assulta'. 'Scrobipalpa' consists of 'Heliopa'. 'Bemisia' consists of 'Tabaci'. 'Myzus' consists of 'Nicotianae'. 'Lasioderma' consists of 'Serricorne'. Each sub-option in-turn classified into 'Parasites', 'Predators' and Pathogens'. 'Parasites' consists of 'Egg', 'Larval' and 'Pupal'. 'Predators' consists of 'Insects', 'Spiders' and 'Vertebrates'. 'Pathogens' consists of 'Bacteria', 'Viruses', 'Fungi', 'Protozoa' and 'Nematodes'. The five level tree was created for each pest for easy classification and accessing.

The knowledge base contains 40 data sheets for 5 major insect pests, which consists of 20 parameters, which are stored as rules of inference that are used during the reasoning process. These rules may be if...then...else nature or any other valid form. The inference mechanism guides the reasoning process through knowledge base by attempting to match the facts in the database to other rule conditions. The 'inference engine' was designed to accept user input

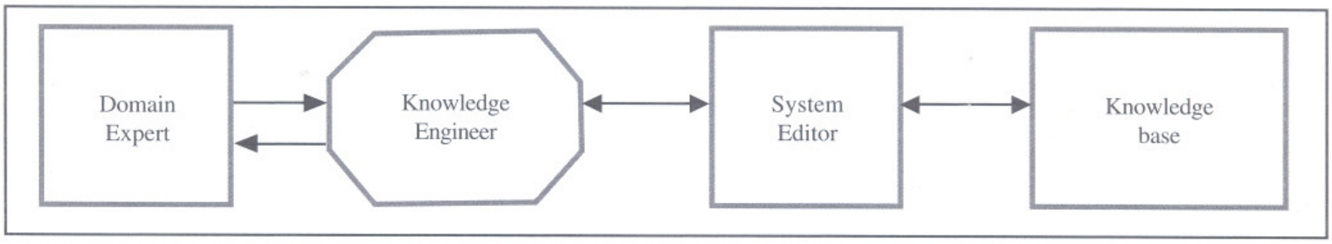

Figure 1. Knowledge acquisition process

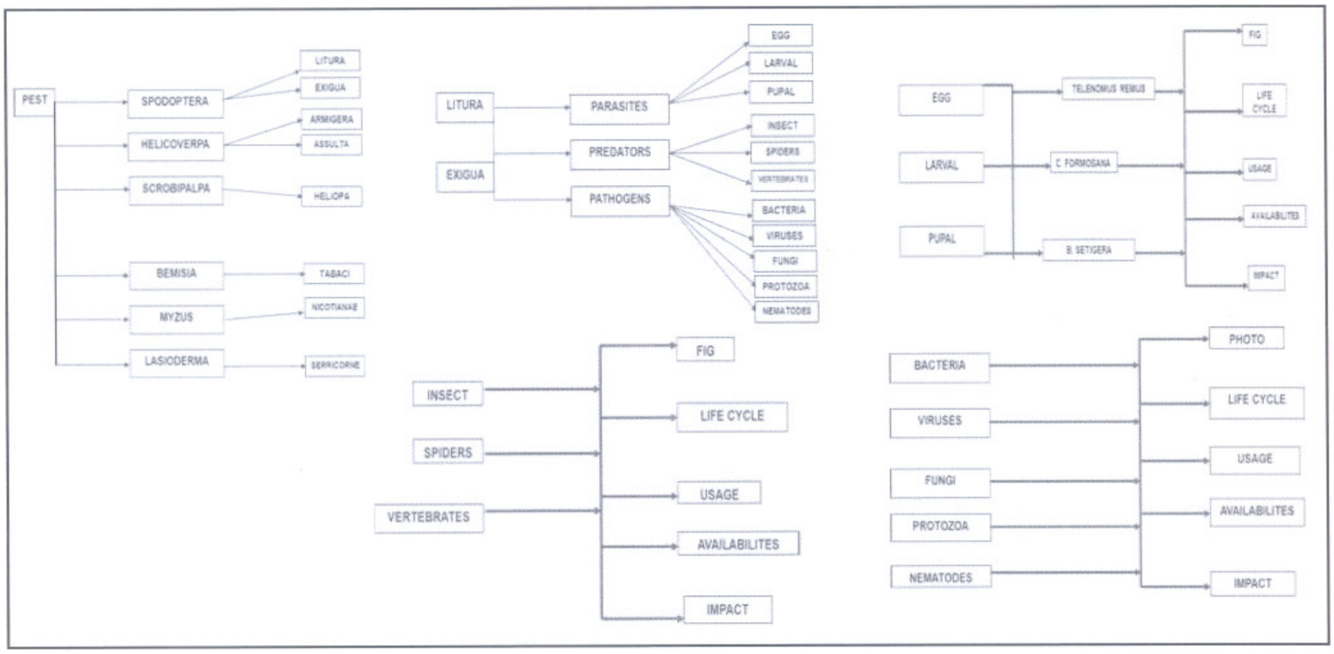

Figure 2. Creation of knowledge base in the form of decision tree

queries and responses to questions through the I/O interface and uses this dynamic information together with the static knowledge stored in the knowledge base.

To use the system easily, the user friendly interface was developed with GUI, which allows the user to communicate with the system in a more natural way by permitting the use of simple selection menus or the use of a restricted language, which is close to a natural language. Through user-interface, the user is allowed to add /update / delete /view the information, view the complete data for a particular agent by selecting the crop name, which is considered as a primary key. Reports were designed using 'Crystal reports' by providing flexibility to the user to view selected parameters and take the hard-copy. Interface was provided to the back-end to access the database from 'Oracle' and to store the new information into it.

Results and discussion

The information collected for designing the knowledge was mainly classified into 5 categories, *viz., Spodoptera, Helicoverpa, Scrobipalpa, Bemisia, Myzus* and *Lasioderma*. The multiple document interface (MDI) form of the software (Fig 3) consists of these five pest names as root of the selection which is considered as primary key. The selection of each pest name itself is a five level tree like "Spodoptera -> Litura -> Parasites -> Egg -> Telenomous" The objects to be displayed after selection are "Photo (biocontrol agent)', 'Life cycle (with photos)', 'Usage', 'Availabilities' and 'Impact'.

These fields were created with text boxes for data entry / modification and label boxes for title of the text. The user can embed image(s) of biocontrol agent and life cycle including 'parasitized' and 'healthy' in the knowledge base itself. Based on the knowledge base, application software has been developed which consists of 5 modules (Fig 4).

The user can view information and generate a hard copy / soft copy of the stored data using 'Report' option. The 'information retrieval' is a powerful tool in this system which allows the user to retrieve and generate a report on the selected pest. According to the selection, the list of the parameters gets displayed. He can view the report for all parameters for that pest. The user can view the complete data for a particular agent like 'Telenomous' by selecting the options like 'Spodoptera -> Litura -> Parasites -> Egg -> Telenomous'. The information for 'Telenomous' *viz.,* 'Photo', 'Life cycle', 'Usage', 'Availabilities' and 'Impact' gets displayed and the hard copy of the same gets obtained (Fig 4).

The left pane of the report screen displays list of parameters for selection and the right pane of the report displays result. The displayed report will be exported to Microsoft word for storing and a hard copy of the same can be taken. The 'Help' option guides the user to execute the software from the beginning. For executing this software, a PC with pre-loaded software of Visual Basic .Net and Oracle are essential.

This is portable software, which makes possible to execute this software in any system. For this, a 'SETUP' program is

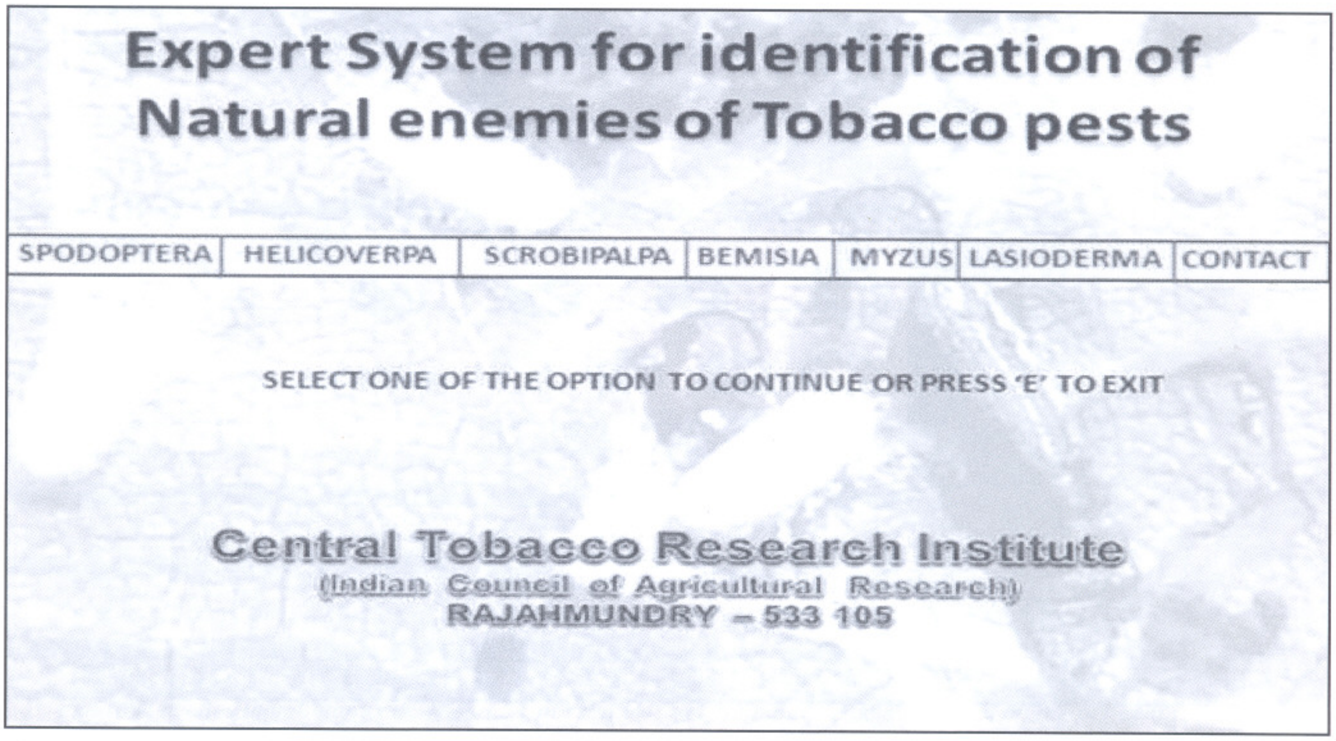

Figure 3. Multiple document interface (MDI) form

created (executable file) including all the files and data. Any user can install this software by running this 'SETUP' program and the execution of the software is self-explanatory.

Extension workers and tobacco farmers often encounter various types of fauna dwelling on plants, above and inside soil. Insect pests of tobacco are recognized correctly to some extent, but natural enemies are many times mistaken for pests damaging crops. This expert system not only imparts identification skill but also directs the non-expert and semi expert clientele about ways to make use of the bio-agents effectively for control of tobacco insect pests. It will help the scientists and extension workers in decision making for integration of bio-control agents in IPM tobacco.

From the researchers point of view, knowledge based systems have a potential to help to organize and synthesize knowledge and information of different types. It is possible to focus and apply diverse avenues of research to solve difficult problems, link together quantitative data, simulation models and basic research results into knowledge base. The idea of an expert system is shifting the focus of the research community to knowledge dissemination in contrast to knowledge accumulation. The expert system in combination with powerful personal computers and devices like CD-ROM has the potential to open whole warehouses of accumulated knowledge for agricultural development.

The main purpose of the expert system is to serve as delivery systems for extension information and management for decision makers. It also plays an important role in agricultural education and helps in dissemination of up-to-date scientific information in a readily accessible and easily understood form to agricultural researchers, advisers and farmers. This expert system is useful for the extension workers and farmers to integrate the biocontrol agents in IPM to minimize the pesticide application, thereby saving the input costs and address the adverse effects due to indiscriminate use of insecticides. Further modification and additions to current system will be a continuous process based on the information and impressions received from various sources. At present, the system is being used by CTRI and planning to make it web based for global accessing.

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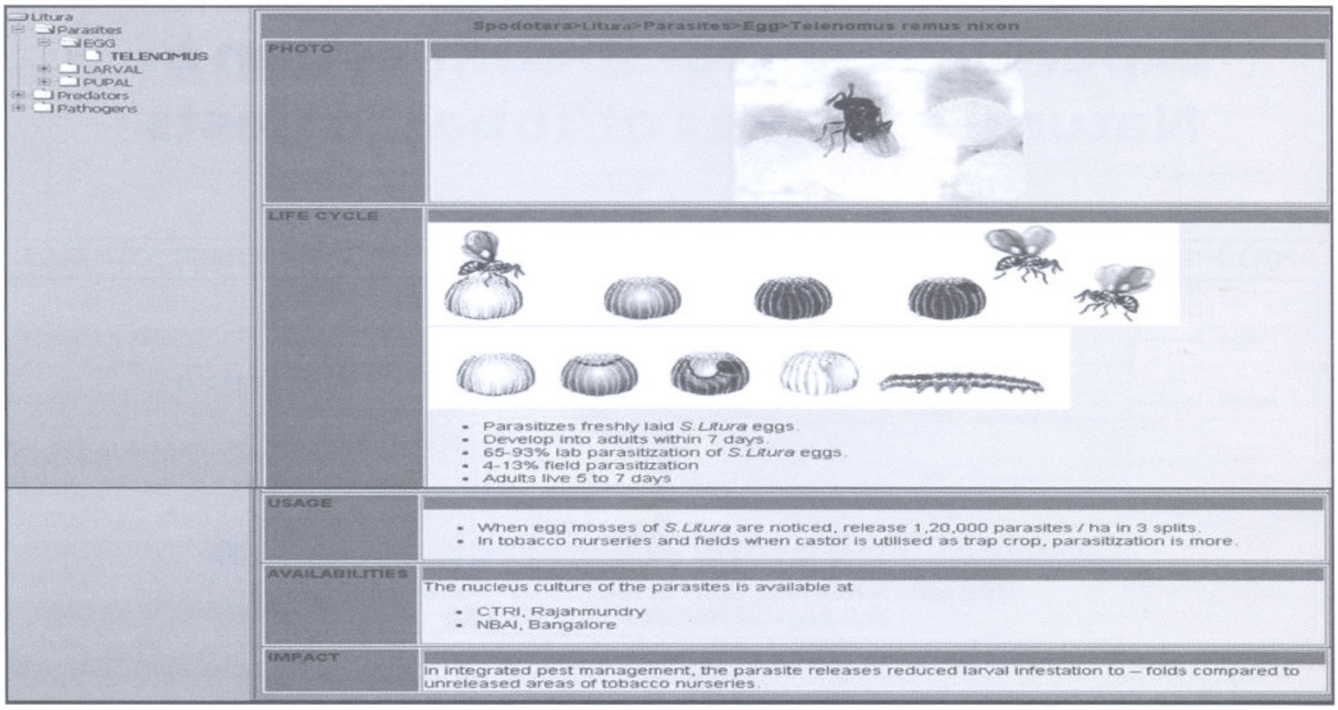

Figure 4. Report menu

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