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Expert system for insect pests of agricultural crops

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ABSTRACT

Insect pests are one of the major constraints in agricultural production, processing and storage. The damage caused by insect pests in agriculture is substantial and farmers have to incur huge monetary losses. Management of insect pests is therefore the only solution to save the crops and other valuable inputs that goes into agricultural production. Vast information on insect pests of different crops and their management is available at different sources. Based on this knowledge, a rule based expert system for insect pests of different agricultural crops was developed. The system is supported by a database containing information about 15 crops with a total of 95 insect pests affecting those crops. The expert system was evaluated following the conventional expert system evaluation methodology. This system provides information and solutions to farmers, scientists, extension workers involved in agriculture development and education. Using this system one can identify the pest and diagnose the problem for speedy and effective decision making in pest management to avoid losses.

Key words: Agriculture, Information System, Pest and Software

Agriculture is demographically the broadest economic sector and plays a significant role in the overall socio-economic fabric of India. India had 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. Lack of good extension services and poor delivery of knowledge and information transfer about plant protection practices are important among the various factors responsible. Pesticide use has enabled farmers to modify production systems and to increase crop productivity without sustaining the higher losses likely to occur from an increased susceptibility to the damaging effect of pests. Insect pest problems in agriculture have shown a considerable shift during first decade of twenty-first century due to ecosystem and technological changes. In terms of monetary value, the Indian agriculture currently suffers an annual loss of about ₹ 8 63 884 million due to insect pests (Dhaliwal *et al.* 2010).

Agricultural production has gradually transformed into a complex vocation requiring the accumulation and integration of knowledge and information from many diverse sources. In order to remain competitive, 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 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. Agricultural Expert System is a Decision Support System 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 (Prasad and Vinaya Babu 2006, Chakraborty and Chakrabarti 2008). It is one of the most efficient extension tool 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. In agriculture, expert systems unite the accumulated expertise of individual scientific disciplines, e.g. Plant Pathology, Entomology, Agronomy, Agricultural Meteorology, etc., (Ravisankar *et al.* 2009a, 2009b, 2010, Denis *et al.* 2002; Adbul-Hadi *et al.* 2006, Ahmed Rafea 2010, Chakrabarti and Chakraborty 2006, 2007) into a framework that best addresses the specific,

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onsite needs of farmers. There are a few expert systems on diagnosis and identification of insect pests specific to some of the crops including pests of oil pam (Chong *et al.* 2008), Tomato (López-Morales *et al.* 2008), Olive crops (Gonzeliz-andujar 2009), Jamican coffee (Mansingh *et al.* 2007) and Solanaceous crops in Greece (Mahaman *et al.* 2003). 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 India also, utility and importance of expert systems are well recognized in agriculture and as a result expert systems have made their presence felt in several facets of Indian Agriculture, especially in horticulture and commercial crops. Most of the institutes under Indian Council of Agricultural Research (ICAR) developed the expert systems for various purposes and are available in areas including crop production, disease management, farming system research, poultry management, animal husbandry, etc. These systems have extensive use in the areas of fertilizer application, crop protection, farm advisory, irrigation schedule, and diagnosis of diseases in paddy and post-harvest technology of fruits and vegetables. In the present study, a rule based expert system (Ajith Abraham 2005) for identification and management of insect pests of 15 agricultural crops was developed which enables the extension personnel, researchers and farmers in identification and management of insect pests.

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 pests and crops was gathered from the experts including scientists, extension workers, farmers and other print sources. For this expert system, the domain expert is the "Agricultural Scientist - Entomologist". The information about the pest, taxonomy, biology, geographical distribution, host plants, identification, nature of damage, natural enemies, various control options and integrated management which are essential for management of insect pests were gathered and catalogued. 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. The knowledge base contains information on 15 crops and 95 pests (Table 1) infecting these crops which consists of 24 attributes clustered into 10 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 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 pest information, view the complete data for a particular insect pest by selecting the crop name which is considered as a primary key. One powerful tool in this system is by identifying the photo of the crop followed by pest, the user can retrieve the complete information for a particular pest. 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

This expert system was developed with graphical interface through which the user can easily access to the required information. The user can acquire information by entering into the expert system through the crop (or) pest name. For example, if the user enters through the pest name by scientific / common / colloquial name, then list of crops will be displayed. By selecting the crop name, he can search the information on the pest biology, nature of damage, control measures and get the report with photos. It is a simple menu driven system which allows the user to execute the sequence of menus by simple selection of various options without asking queries.

Due to vague and incompleteness of diagnostic knowledge, pest identification as a decision making process leads to some uncertainty. So, the design of expert system should provide methodologies to attend inaccurate and incomplete information (Tocatlidou *et al.* 2002). There are some techniques in knowledge engineering to manage or correct the user uncertainty. The techniques such as Fuzzy Logic, Dempster-Shafer theory are some of the techniques

Table 1 Crops and pests included in the knowledge base

Crop	Pest
Rice	Helicoverpa armigera, Mythimna separata. Nephotettix virscens N nigropictus, Nilaparovata lugens, Nymplmla depunctalis. Cnaphalocrocis medinalis guenee, Orseolia aryzae, Scirphophaga incenulas
Maize	Rhophabsiphum maidis, Sesamia inferens, Chilo parielhts, Atherigona soccata, Peregrinus maidis, Hieroglyphus nigrorepletus, Mythimna sepccata
Sugarcane	Chilotarea auricilius, Scirpophaga nivella, Polyocha depressella, Saccharicoccus sacchari
Piegonpea	Melanagromyza obtusa, Mylabris pustulata, Lampides Boeticus, Otinoms oneratus. Maruca vitrata, Etiella zinckenella, Helicoverpa armigera
Greengram	Spodoptera litura, Bemisia tabaci, Aphis craccivora, Empoasca korri, Maruca vitrata
Groundnut	Aphis craccivora. Aproaeretna modicella. Caliothrips indices, Scirtothrips dorsalis, Lachnosterna onsanguinea blanchard, Empoasca kerri, Spodoptera litura, Amsacta albistriga.
Sunflower	Empoasca kerri, Trialeurodes vaporariorum westwood, Aphis craccivoras, Spodoptera litura, Helicoverpa armigera, Thysanoplusia orichalcea Fabricius, Spilosoma obliqua Walker
Chilli	Polyphagotarsonemus latus, Scirtothrips dorsalis. Spodoptera litura, Helicoverpa armigera, Mysus persicae
Bhendi	Helicoverpa armigera, Liriomysa trifolii, Spodoptera litura, Bemisica tabacci Erias vitella, Aphis gossypii, Amrasca biguttula biguttula, Erias insulana.
Brinjal	Idioscopus cfypealis, Idioscopus niveosparsus, Amritodus atkinsoni, Drosicha stebbingii, Chlumetia transversa. Aspidiotus desmicwr, Apsylla cisteliata. Sternochetus mangiferae. Caliothrips indicia BangalL Deanolis albizonalis. Orthaga exviitacea Hampson, Bactrocera dorsalis, Leucinode orlsanalis
Tomato	Cosmopolites sordidus, Colaspis hypochlora Chetanaphoth-ips signipennis, Pentalonia nigronervosa, Liriomyza trifolii, Helicoverpa armigera, Thrips tabaci
Cotton	Aphis gossypii, Helicoverpa armigera, Pectinophora gossypiella, Tetraiychus cinabca-inm Boisduval, Earias vittella Fabricius, Amrasca biguttula bigutnda, Bemisica tabaci
Banana	Cosmopolites sordidus, Pentalonia nigronernosa, Bemisica tabaci, Coccidohystrb: insolita, Gargaphia solani Heidemann. Popillia japonica, Epilachria Figimioctopunctata (Fabricius), Herpetogramma biptmctalis, Pbytoplasm sp, Tetramyclms laticae, Leitcinodes orbonalis, Eiaophera perticella, Amrasca biguttula biguttula
Coconut	Opisina arenosella, Aspidiotus destructor, Rhynchophorus ferrugineus, Parasa lepida Cramer, Oryctes rhinoceros, Aceria Guerreronis Keifer
Cashew	Plocaederus fermgineus, Scirtothrips dorsalis, Helopeltis antonni sign

available to remove the uncertainty. In our expert system, we introduced an approach to handle the vagueness associated with diagnostic knowledge by not giving any numerical values to the most of the qualifiers. Image based diagnosis play an important role in the agriculture. The present system includes images with detailed symptoms of damage, different stage of insects for easy identification. This software was developed in such a way that there were no questions to the users and colloquial/common names were included so that there will be no vague in the diagnostic knowledge.

The information collected for designing the knowledge was mainly classified into 2 categories, viz. Crop Master and Pest Master. The objects included in the Crop Master are Crop Id, Crop name and Crop photos and the objects included in Pest Master are Pest Id, Pest photo, Pest Scientific name, Order, Family, Sub-family and Biology. Crop Id and Pest Id were selected as a primary key.

These fields were created with text boxes for data

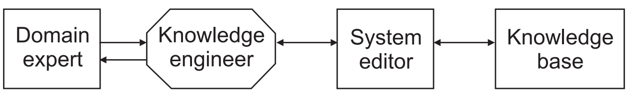

Fig 1 Knowledge acquisition process

entry/modification and label boxes for title of the text. The user can embed image(s) of crop and pest photos in the knowledge base itself. Based on the knowledge base, application software has been developed which consists of 20 modules. The multiple document interface (MDI) form of the software (Fig 2) consists of 4 options, viz 'Masters, 'Details', 'Reports', and 'Help'.

The 'Masters' option allows the user to add a new crop and pest details. The 'Details' option consists of 3 sub options, namely 'Pest-history', 'Other details' and 'Control measures'. The 'Pest-history' option provides an environment to select 'crop name' and 'pest name' from the drop down box which are entered previously in the master's option. The user allowed to enter the 'common names' and 'colloquial names' related to the pest and crop displayed in that menu.

The 'Other details' option allows the user to add/update 'Geographical distribution', 'host plants', 'identification', 'nature of damage' and 'natural enemies' information with photos. The 'Control measures' option allows the user to add / update the information related to 'Biological control', 'Chemical control', 'Cultural control', 'Mechanical control', 'Resistant varieties' and 'IPM'.

The user can view information and generate a hard

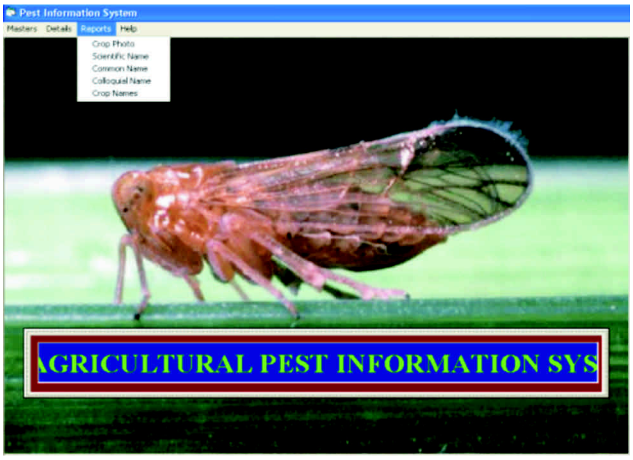

Fig 2 Multiple Document Interface (MDI) form

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 various selections, viz. Selection by photograph, common name, colloquial name, scientific name and host plant. According to the selection, the list of the parameters gets displayed. The user has to select 'all' followed by 'show report' option to view the report for all parameters for that pest (Fig 3). Some of the results of the developed system are given below.

Rule : Display the information from database Where crop-name = 'Tobacco' and Scientific name = 'Heliothis Armigera'

The left pane of the report screen displays parameters information and the right pane of the report displays the photo of the pest/biology/nature of damage/natural enemies/ identification. 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.

In this expert system there are 15 economically important crops grown in India and 95 pests damaging these crops. The crops included are some of the cereals, pulses, vegetables and horticultural crops. It is an advantage to the clients involved in cultivation of different crops in different agro-climatic zones of India to get information/ diagnosis of pests damaging the crops. There are excellent photographs of pests, damaging parts and symptoms which will help for correct diagnosis and to take timely control measures. This is of great importance in integrated pest management in which all the pests are to be taken into account along with the natural enemies if an appropriate management strategy is to be applied. This expert system will be useful for the agricultural research, education and extension workers.

This is portable software, which makes possible to execute this software in any system. For this, a 'SETUP' program is created (executable file) including all the files

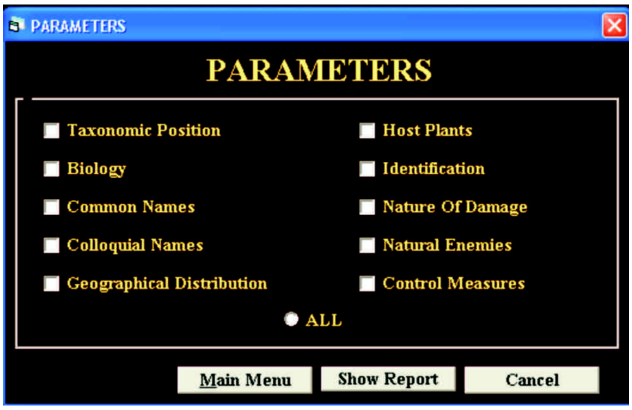

Fig 3 List of parameters

and data. Any user can install this software by running this 'SETUP' program and the execution of the software is self-explanatory.

CONCLUSION

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 instrument in agricultural education. It helps in dissemination of up-to-date scientific information in a readily accessible and easily understood form to agricultural researchers, advisers and farmers. With the help of the expert system, the farmers can produce higher quantity and quality agricultural produce by using optimum resources. Even though, this expert system is containing many of the economically important damaging pests reported in India, there is a possibility of using this system by the neighboring countries facing similar pest problems due to the similarity in climatic conditions and agro eco systems, and this system will be fit to the needs after adapting to the local pests. Further modification and additions to current system will be a continuous process based on the information and impressions received from various sources. The present expert system is a stand alone one. In the future, it is planned to develop a web based version of the expert system that would make accessibility to anyone having a system with net connectivity in different locations.

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