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Use of Multimedia Bilingual Expert Systems in Promoting Sustainable Integrated Pest Management Techniques of Chickpea to Conserve Eco-system

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Abstract—*The excessive use of chemical pesticides are a cause of wide spread ecological imbalance. This results in serious problems of pesticide residues and pesticide resistance. There is a need for promoting environmentally sustainable agriculture practices in the world. Integrated pest management is the globally accepted strategy for promoting sustainable agriculture.IPM comprises of various pest and disease management strategies. Expert systems can be efficiently used in promoting sustainable IPM techniques to farmers, extension workers, students and researchers by incorporating multimedia and regional languages for better understandability of the farmers.*

In this paper, a multimedia bilingual expert system for insect management in chickpea is described. The expert system has two version the user version and the administrator version and it operates on two languages Hindi and English. The expert system has two modules. The first one is the information system which gives information about various aspects of chickpea cultivation including various insect, disease, weed, nutritional disorder, nematodes management. The second module is a diagnostic block in which the system asks for inputs regarding the damage caused by the insect and morphology of the insect to diagnose the insect. This module is based on certainty factor which is provided by the domain expert. The incorporation of multimedia tools like pictures, sound and videos has enhanced the effectively of the system.

1. INTRODUCTION

India is also largest consumer as well as importer of chickpea in the world. In India, chickpea is grown on about 9.21 million ha producing 8.88 million tons of grain with productivity of 995 kg/ha. Chickpea contributes 36% and 48% to the national pulse acreage and production, respectively. Madhya Pradesh, Maharashtra, Rajasthan, Uttar Pradesh, Andhra Pradesh, Karnataka and Gujarat are the major chickpea producing states sharing over 80% of the area. Among chickpea growing states, Andhra Pradesh registered highest productivity (1448 kg/ha) followed by Bihar (984 kg/ha), Gujarat (977 kg/ha), Madhya Pradesh (850 kg/ha), Maharashtra (825 kg/ha), Uttar Pradesh (745 kg/ha), Karnataka (607 kg/ha) and Rajasthan (466 kg/ha). The current growth rate (6.32%) in production and productivity of chickpea is increasing in recent years but it is still low as compared to population growth due to various agro-ecological, biological, institutional and socio-economic constraints [8].

Pod borer *(Helicoverpa armigera),* semilooper *(Autographa nigrisigna),* cutworm *(Agrotis ipsilon)* and termite *(Odentotermes obescus)* were justified as major insect-pests of chickpea. However, *H. armigera* is the key pest causing up to 95% damage. Lately, the entire attention has been focused on development of integrated pest management strategies for *H. armigera.* [8].

Integrated Pest Management (IPM) is a strategy to prevent and suppress pests with minimum impact on human health, the environment and non target organisms.

IPM is a systematic approach to pest management that focuses first on preventing problems. It involves monitoring pest populations, identifying pests and choosing a combination of tactics to keep pest populations at an acceptable level. Tactics may include cultural, mechanical, biological and chemical methods of pest management. IPM stresses trying the least toxic methods first.

Insect pests, diseases and weeds are the major constraints limiting agricultural productivity growth. It is estimated that herbivorous insects eat about 26 percent of the potential food production. Emerging problems of insecticide resistance, secondary pest outbreak and resurgence further add to the cost of plant protection. Annual crop losses due to insect pests and diseases in India are estimated to be 18 percent of the agricultural output. Losses caused by specific pests may be higher [7].

Expert systems play an important role in supporting farmers to practice effective integrated disease and insect management techniques and taking decisions on crop protection where the

experts are not available. In agriculture, expert systems unite the accumulated expertise of individual disciplines, e.g., plant pathology, entomology, horticulture and agricultural meteorology, into a framework that best addresses the specific, on-site needs of farmers. Expert systems combine the experimental and experiential knowledge with the intuitive reasoning skills of a multitude of specialists to aid farmers in making the best decisions for their crops. [5].

2. EXPERT SYSTEM

Expert system is a branch of Artificial Intelligence which focuses on making computer programs which can reasons like humans. An Expert System also called a Knowledge Based System is a computer program designed to simulate the problem-solving behavior of an expert in a narrow domain or discipline.[4]. An expert system can be designed based on mathematical model, statistical model, neural network, database knowledge base or combination of one or more techniques. The present work embodies a knowledge based expert system. Collections of different forms of IF-THEN rules are organized in the knowledge base of the expert system.

Expert system also uses human knowledge to solve problems that normally would require human intelligence. It represents the expertise knowledge as data or rules within the computer. These rules and data can be called upon when needed to solve problems. Books and manual guides have a tremendous amount of knowledge but a human has to read and interpret the knowledge for it to be used. The idea behind creating an expert system is that it can enable many people to benefit from the knowledge of one person - the expert [4]

Expert systems have been successfully used in various diversified fields like medicines, control systems, fault diagnosis, financial forecasts, planning, agriculture etc. Expert systems are now being widely used in various sectors of agriculture [2]. It is an information system that has been used to solve a problem that usually requires an expert to solve.

3. COMPONENTS OF EXPERT SYSTEM

A typical expert system has the following four components (shown in Fig. 1) i.e.

- Knowledge base (KB)
- Inference engine (IE)
- Control Strategy(CS)
- User interface (UI)

a) Knowledge Base: A knowledge database stores two important things: facts, and rules or heuristic rules. The process of building expert systems is called knowledge engineering. The knowledge engineer is responsible for structuring the knowledge for the expert system in form of IF (Antecedent) THEN (Consequent) rules. The components and their interaction will be refined over the course of numerous meetings of the knowledge engineer with the experts and users. These structured rules are organized into the knowledge base (KB).

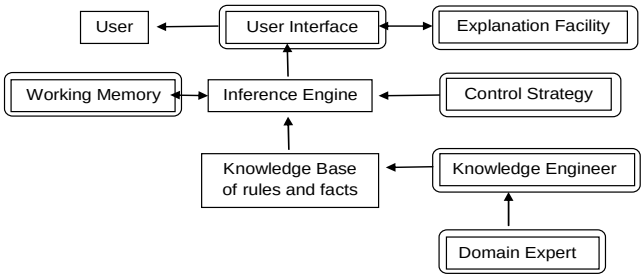

Fig. 1: Standard Architecture of Expert Systems

b) Inference Engine: The inference engine is the most important component and is considered the "Brain" of an ES. The inference engine is the knowledge process that is modeled on the methods of human expert reasoning. It is a process in the Expert System that pairs the facts stored in the working memory with the knowledge domain that is stored in the knowledge database, to get the method from the problem.

c) Control Strategy: The knowledge is processed by the inference engine using the control strategy (CS) for achieving expert advice. There are two strategies used by the inference engine when making decisions or conclusions. These strategies are forward and backward chaining. In forward chaining strategy the inference engine starts reasoning from the facts provided and moves on until it achieves its decision or conclusion. In backward chaining It starts from the decision and moves backward to obtain supporting facts for the decision made. If there are no matching facts that support the chosen decision, the decision will be rejected and another decision will be selected. The process continues until a suitable decision and the facts that support it are obtained.

d) User Interface: The user communicates with the Expert System through the user interface. It enables the user to query the system, input information and receive advice.

Some optional components of expert system are:

1. Explanation Facility: The advice given by the system is explained by making use of explanation facility.
2. Working Memory: The working memory (WM) represents the set of facts known about the domain. The elements reflect the current state of the world. In an expert system, the WM typically contains information about the particular instance of the problem being addressed [5]

4. DEALING WITH UNCERTAINTY AND CERTAINTY FACTOR

In agriculture, the information or knowledge available is often vague or inexact. There is uncertainty associated with every

step. To handle uncertainty in this case, certainty factors have been used. In Expert systems the word uncertainty is related to the working with inexact data, imprecise information, handling identical situation, reliability of the results etc. An expert system allows the user to assign probabilities, certainty factors, or confidence levels and many more techniques to any or all input data. This feature closely represents how most problems are handled in the real world. An expert system can take all relevant factors into account and make a recommendation based on the best possible solution rather than the only exact solution to handle such problems[1].

Uncertainty can be defined as the lack of the exact knowledge that would enable us to reach a perfectly reliable conclusion. This is because information available to us can be in its imperfect, such as inconsistent, incomplete, or unsure, or all three forms. There are many approaches to representing uncertainty in Artificial Intelligence. Some of them are:

- Abductive reasoning
- Property inheritance
- Fuzzy logic
- Certainty Factor (CF)
- Bayes theorem
- Dempster-Shafer theory

Certainty factor is method of dealing with uncertainty. Certainty factors represent information about how certain the conclusion in a rule may be. Certainty factors can be attached both to the conditions in an if-then rule and to its conclusion. They are adhoc values, given by the experts based on experience or by the users when providing initial data. A Certainty Factor or CF with a value of 1 indicates total belief, whereas a CF with a value of -1 indicates total disbelief. Certainty factors are measured using various scales both numeric (0 – 100, 0 – 10, 0 – 1, -1 to- 1) and linguistics ones (certain, fairly certain, likely, unlikely, highly unlikely, definitely not).If the certainty factor ranges between 1 to -1 then

- Higher certainty factors indicate strong confidence in a hypothesis.
- Certainty factors that approach -1 indicate confidence against a hypothesis.
- Certainty factors around 0 mean that we don't have information either for or against a hypothesis

In the present work, certainty factor or the confidence factor has been used for development of diagnostic block in expert system for Insect management in chickpea.

5. DESCRIPTION OF THE SYSTEM

The development of the Multimedia Bilingual Expert System for Pest Management in Chickpea has been done in two phases:

1. Designing of the Web Based Information System
2. Development of Diagnostic Expert System for Insect Management in Chickpea.

Information system (IS) is an important embranchment of computer application field and has been widely used in agriculture area, such as crop planting, seed breeding, livestock & fowl breeding, soil fertilizer, irrigation, plant protection, farming mechanization, agricultural district, weather service, agricultural science document and information management etc. Web technology has developed rapidly and has been accepted by lots of people for its using standard Browser via HTTP(Hyper Text Transfer Protocol) to display multimedia information such as image, movies, sounds and so on, which leads great changes in architecture, functionality, and development environment of traditional information system.

The diagnostic expert systems are based on knowledge (Knowledge Based Engineering KBE). The knowledge is stored in the knowledge database to support the diagnosis of technical objects. Expert systems are usually sophisticated computer programs capable of obtaining and recording the diagnostic knowledge of a specific area of operation of objects. Knowledge can then be used repeatedly to perform tasks related to the area of operation.

Knowledge management for the development of the information system was done in three stages.

- Knowledge acquisition
- Knowledge Structuring and representation
- Knowledge organization and processing.

Knowledge has been acquired from internet search user and domain expert interviews and literature references. Literature references include published literature consists of books, disease and insect management guides, research papers, surveys & reports, extension bulletins and newsletters .Preliminary knowledge has been compiled from IPM books and research papers published in journals, as it is most reliable and trusted [3]. Interviews with the domain experts are very useful in knowledge gathering, Image repository, knowing other sources of knowledge. It is of great importance to know insects attacking the chickpea plant in the Indian as well as agro-climatic zone context. Deciding the certainty factor or the confidence factors for insect diagnosis, pest management and user expectations from the system are some of the activities where expert interviews are of great importance.

For preparation of rule or the knowledge base, knowledge collected from books, domain experts, user, research paper, journals, extension bulletins, annual reports have been summarized. The knowledge available was converted into different IF-THEN rules forms . An example of rule base is shown in Table 1

Table 1: Rule Base for Diagnostic block

Rule Id	Object	Attribute	Value	CF	InsectName
1	Eggs are laid	in	Singles	0.8	Gram Pod Borer
7	Length of Larva	is	25mm	0.9	Semilooper
14	Colour of Larva	is	Grey-Black	0.8	Cutworm
17	The caterpillar drag the cut parts into soil for feeding	is	Yes	0.9	Cutworm
19	Insects bore into root and stem	is	Yes	0.9	Termites
21	White Eggs on stored seeds	is	Yes	0.9	Bruchids
22	Holes made by Insect are	are	Regular	0.9	Gram Pod Borer
25	Tunnels are seen in stem and roots	is	Yes	0.9	Termites
30.	Eggs are laid	On	Pods	0.9	Bruchids

The combined CF of same insect in the rules is calculated using the three equations and the insect with the highest CF is the insect identified in the process.

CF(P and Q) = min(CF(P), CF(Q)) ....(1)

CF(P or Q) = max(CF(P), CF(Q)) ..... .(2)

CF COMBINE(CF1,CF2)= CF1 + CF2*(1-CF1)..... ..(3)

The knowledge gathered from the experts, literature, farmers has been organized in MYSQL database. MYSQL is an RDBMS.(relational database management system). A database DBChickpea has been created for management and processing of data in the knowledge base of the system. This database will be used as back end for the Web based Information system for Chickpea cultivation and as well as rule base for the expert system.

In DBChickpea MYSQL database, 21 tables have been created to store information about different aspects of chickpea cultivation and for creating rule base for the diagnostic blocks. Separate tables have been created to store data in hindi also. Master tables are created to store data which is been entered through the user interface. The user interface for the information has been designed into two versions, using PHP (Hypertext Preprocessor), firstly the administrator version and secondly the user version. The front page or the home page of the system has two menus .i.e one horizontal and other vertical menu. The horizontal menus has 8 menu items. Fig. 2 shows the web page design for English version.

The user can get information about package of practice for chickpea by clicking on the left picture menu. The system provides information starting from land preparation to finally harvesting methods used in chickpea crop production. If the user clicks the Hindi version the system provides information in Hindi. If the user selects the soil and climate option from the left image menu in the hindi version the information about soil selection and climate requirements are provided in hindi language.(Fig. 3). Fig. 4 shows the landpreparation.php form displaying information about preparation of land for chickpea cultivation.

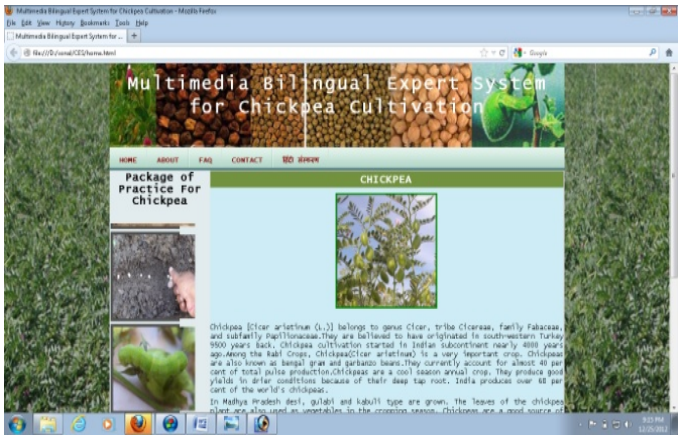

Fig. 2: Home page of the system.

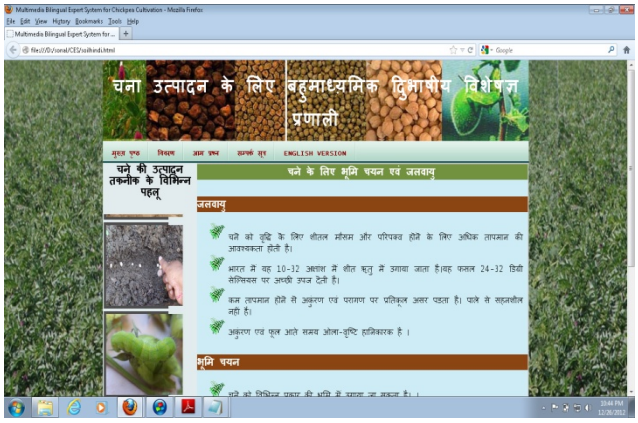

Fig. 3: Soilhindi.php form in hindi version.

Fig. 4: Land Preparation form in English version

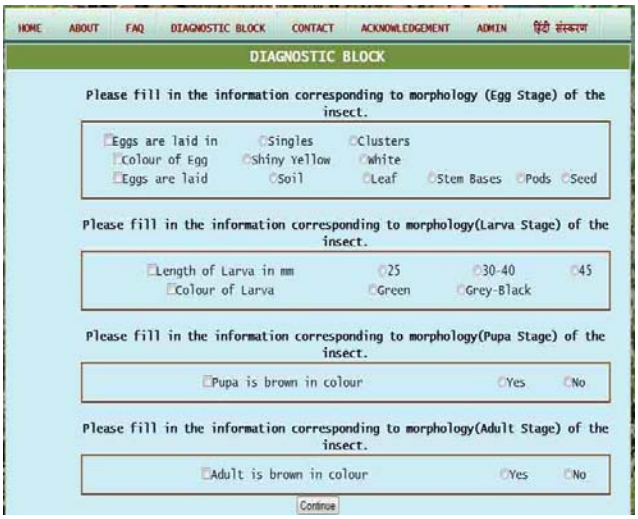

Fig. 5: Diagnostic block

Fig. 6: Diagnostic block form

The diagnostic expert system for Insect Management can be used by clicking the DIAGNOSTIC BLOCK in the home.php page. The system will ask the user, series of question and user has to answer them in 'yes' or 'no'. In the end the system displays the result showing the insect name and photo with highest probability based on user inputs. The system will work in both languages English and Hindi. Fig. 5.6 and 7 show the diagnostic blocks forms and the result shown by the system.

Fig. 7: InsectResult.php form

Fig. 8: Insect Details

Clicking on the Insect Details button (Fig. 7) we get the details of the insect, its common name, scientific name, damage caused by it, symptoms and control measures (Biological, mechanical, agronomical and chemical controls), their ETL (Economic threshold level) along with photograph.

6. RESULT AND TESTING

The sample runs of the expert system shows the various input and output features of the system. The results of insect diagnosis were tested before their actual implementation with 50 sets of data covering various possibilities for insect identification. The software produced results of good quality and precision similar to expert advice in IPM. The details of the chickpea cultivation from soil selection to storage were also found educational and beneficial by the users. Since the software is in hindi, the common user of the computer can also operate the system efficiently. Incorporation of multimedia was appreciated by the end user.

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