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Short communication

A brief survey of computerized expert systems for crop protection being used in India

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Abstract

In the recent years, a plethora of computerized expert systems has been developed for various sectors of agriculture in India. The availability of low-cost computers, agricultural knowledge and information technology professionals are the principal reasons for the development of so many agricultural expert systems. Among all agricultural expert systems, the expert systems for crop protection need special mention. These expert systems are meant to be used by farmers and other persons without much experience of using computers. Hence, special care must be taken while developing them. The current paper develops a taxonomy for the expert systems for crop protection and briefly discusses four such expert systems for crop protection being used in India.

Keywords: Computerized expert system; Agriculture; Agricultural expert system; Crop protection

1. Introduction

Approximately two-thirds of all Indians depend on agriculture for their livelihood either directly or indirectly. The area cultivated is considerably more than the half of the total area of the country. In the more fertile areas, like the northern plains and the deltas on the eastern coast, the proportion of cultivated area to the total area generally exceeds 90%. Since the late 1960s, agricultural technology in India is undergoing rapid changes. Extension of irrigation projects, increased use of chemical fertilizers and pesticides, and introduction of high-yielding variety seeds are a few changes to name.

However, pests and diseases still continue to be a major threat to the agricultural productivity in India. Every year the Indian farmers incur heavy losses due to these pests and diseases. As a result, the protection of crops from various pests and diseases has emerged as the greatest challenge for the agricultural science and technology community in India. A large volume of data and information has been generated by the agricultural research community over the years, but the field implementations of the results of these researches are not as successful as they should have been. Although scores of material are available as scientific publications, popular articles and extension bulletins, the farmer community does not have a proper access to them. Consequently, the farmers in India continue to suffer.

The beginning of the widespread use of computers and information technology in India in the 1990s proved to be beneficial to the Indian agriculture. Apart from other utilities, the help also came as agricultural expert systems. An expert system can be defined as a piece of computer software that uses encoded knowledge to solve problems in a specific domain that normally requires human expertise [1]. Soon after that, there was an explosion in the number of agricultural expert systems for a vast domain of activities in agriculture including crop protection, irrigation, soil management and nutrient management. The current paper aims to provide a brief timely survey of the

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present trend rather than performing in-depth review and analysis of the technology. It discusses the design and implementation issues of agricultural expert systems in general and expert systems for crop protection in particular. The paper also provides concise overviews of four expert systems for crop protection that are being successfully used in India.

2. The agricultural expert system explosion in India

In the last decade, expert systems have been developed for almost all sectors of agriculture in India. They include expert systems for pest management, crop selection, soil preparation, animal husbandry, fisheries and food processing. Though the current paper focuses on expert systems for crop protection, there are four common reasons for the explosion in the number of agricultural expert systems in India.

The first important reason for the sudden increase in the number of agricultural expert systems in India is the availability of low-cost computers. The advent of economic computer systems that are affordable to big and even medium-sized farm owners has been a driving factor for the development of a large number of agricultural expert systems. The second important reason is the availability of information and knowledge from long-term research in agriculture. Most of this information has been generated from systematic research in both laboratory and field conditions sponsored by various government and non-government agencies. Thirdly, a respectable number of information technology professionals are now available to design and implement the agricultural expert systems. Last but in no way the least, is the boost in computer literacy and interest among the rural and agrarian societies that has significantly helped in the proliferation of the agricultural expert systems.

3. Design and implementation issues of expert systems for crop protection

Developing an expert system for crop protection is not a trivial task. Several issues are required to be considered during the design and implementation stages. Some of these issues are quite different from the issues in developing expert systems in other domains [1].

The expert systems for crop protection are meant to be used directly by the farmers and the extension workers. Although a formidable part of this clientele group may be computer literate, none of them are proficient computer users. The expert systems for crop protection should be such that this class of users finds them easy to use. Another sensitive issue is the use of the local languages that will help the expert systems for crop protection to spread to farmers who are not very fluent in English. The key issues for success of expert systems for crop protection have been identified and listed next.

(1) *User friendliness.* The expert systems should be easy to use. They should not ask too many questions as that may overwhelm most users. The questions should be straight forward and their answers must be well defined.
(2) *Use of local languages.* Since all farmers are not well versed in English, the expert systems should support local languages to reach a larger audience.
(3) *Simple user interfaces.* The user interfaces of the expert systems must be kept as simple as possible. The questions should be asked one by one and the expert systems should not display too much information at a time.
(4) *Use of photographs.* The expert systems should use photographs of pests and diseased plants to help the users to correctly identify the symptoms.
(5) *Use of interactive controls to avoid typing.* Since most users are not habituated to use computers, the expert systems must use interactive controls like radio button, check box, dropdown list and list box to minimize the need of typing.
(6) *Option for printouts.* Option to print a copy of the diagnosis and the proposed treatment must be available.
(7) *Standalone systems.* Since the farmers seldom have any proficiency in using computers, the expert systems should be standalone systems and the users must not need to use any other software.
(8) *Setup program.* The expert systems must come with simple setup programs so that the users can themselves install the expert systems on their computers.

The development of an expert system for crop protection is a dynamic process rather than a one-time activity. The occurrences of most crop diseases are greatly influenced by the changes in the environmental and edaphic conditions of the region. The disease scenario is also affected by the introduction of new crop varieties. Therefore, an expert system for crop protection should be updated regularly using the feedbacks obtained from the fields. To develop a reliable expert system for crop protection, the various factors that may influence the occurrences of the diseases in the crops must be tracked continuously for at least 10 years.

The working of most expert systems for crop protection can be broadly divided into two mutually exclusive and exhaustive phases. A typical first phase deals with the diagnosis of the pest or the disease from the available symptoms. Alternatively, a typical second phase deals with the prescription of proper preventive or curative measures. Most expert systems for crop protection use some form of backward chaining of logic to implement the first phase and some form of forward chaining of logic to implement the second.

4. Examples of expert systems for crop protection

At this point of the paper, a taxonomy of expert systems for crop protection should be formalized. Two parameters

that can be used for the classification of these expert systems for crop protection are crop specificity and disease specificity. An expert system for crop protection can be developed either for a specific crop or a number of crops. A crop specific expert system for crop protection, in turn, may be developed either for a specific disease or a number of diseases of the specific crop. Accordingly, there are three types of expert systems for crop protection, viz., crop nonspecific, crop specific and disease nonspecific, and crop specific and disease specific, as shown in Fig. 1. Four expert systems for crop protection that are being used successfully in India have been tabulated in Table 1. A brief account of each of them is given next.

4.1. Pesticide Advisor

The Pesticide Advisor [2] is a suitable example of crop nonspecific expert system for crop protection. The Pesticide Advisor has been developed to choose the most effective and safest pesticides, and apply them correctly in the optimum doses. It is easy to use and interactive tool to suggest preventive and curative pesticides to manage the most menacing pests for almost all important crops grown in India. It is meant to be used in the fields by the farmers as well as for research by scientists, researchers and students. The Pesticide Advisor plans its treatment policies using 198 pesticides for over 723 pests that affect 94 crops. It has detailed information about the pesticides including their target pests, shelf lives, manufactures, chemical formulae and safety measures. The expert system also proposes the use of the less hazardous biopesticides instead of the conventional chemical pesticides whenever possible. The Pesticide Advisor provides the information in a step by step manner and supports the generation of customized case reports.

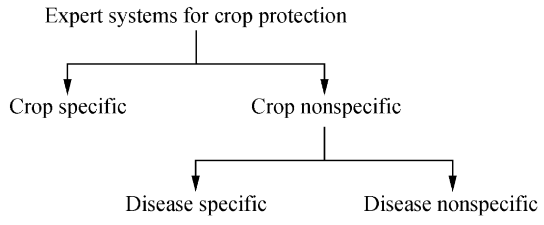

Fig. 1. Classification of expert systems for crop protection.

4.2. Expert System for Pest and Disease on Different Field Crops in India

The Expert System for Pest and Disease on Different Field Crops in India [3], abbreviated as ESPDDFCI, is another example of crop nonspecific expert system for crop protection. It has been developed for identifying pests and diseases on the basis of various distinguishable symptoms. Widespread use of appropriate photographs has been made to help the users to correctly specify the symptoms. After the diagnosis, the ESPDDFCI proposes well practiced scientific control measures for the diagnosed pest or disease. The expert system is meant for the use by farmers, extension workers, scientists and agricultural researchers. The database used by the ESPDDFCI expert system can be updated from time to enhance the scope and the efficiency of the expert system. The provision for generating hardcopy reports is also available. Self-explanatory help and information features have been extensively used in the expert system. A simple setup program has been developed so that even the naive users can install the expert system on their own computers. The ESPDDFCI has the unique feature of supporting several local Indian languages.

4.3. Indian Cotton Insect Pest Management

The Indian Cotton Insect Pest Management [4], abbreviated as ICOTIPM, is a crop specific and disease nonspecific expert system for crop protection. The expert system is meant to be primarily used by the cotton farmers. ICOTIPM uses the domain knowledge of entomologists engaged in research on cotton insect pests in India for making appropriate pest management decisions. The user interface is purposefully kept simple. It deals with all possible scenarios and provides descriptive photographs keeping in mind that the users may not be familiar in using computers. The expert system diagnoses the pests either by the description of the damages done to the plants or by the photographs of the insects. After the diagnosis, the expert system proposes a concrete pest management strategy specifying the pesticides to be used, their dosage and their application techniques. The ICOTIPM expert system has been provided with help and print options for the convenience of the users. The ICOTIPM is a standalone program and does not require the support of any other software for its smooth operation.

Table 1
Examples of expert systems for crop protection

Expert system	Attributes		Crop (if crop specific)	Disease (if disease specific)
	Crop specificity	Disease specificity		
Pesticide Advisor [2]	Nonspecific	Nonspecific	NA	NA
ESPDDFCI [3]	Nonspecific	Nonspecific	NA	NA
ICOTIPM [4]	Specific	Nonspecific	Cotton	NA
ESMMDM [5,6]	Specific	Specific	Mango	Malformation

4.4. Expert System for Management of Malformation Disease of Mango

The Expert System for Management of Malformation Disease of Mango [5,6], abbreviated as ESMMDM, is a crop and disease specific expert system for crop protection. It has been developed for the use of farmers and agriculture extension workers. ESMMDM predicts the incidence of the malformation disease in the mango crop and suggests an appropriate integrated management scheme for its cure. Etiological and epidemiological knowledge accumulated from long-term research under both laboratory and field conditions has been used in this expert system. The expert system is designed to operate for a large span of geographical and climatic conditions. It uses a fuzzy logic-based reasoning process to overcome the incompleteness and impreciseness in the inputs provided by the users. The ESMMDM is a window based, user friendly and interactive software. A series of questions is asked to the user to reach the correct inference about a particular case. The questionnaire is in the form of multiple choice questions. The users are required to select one of the options from an interactive control like a radio button or a dropdown list box. The questions have been designed in a simple language and appropriate photographs have been used to help the users to accurately specify the symptoms. The expert system can be used by any person with or without any skill in using computers. It can be used to generate a comprehensive report of the current case. The report includes the details of the symptoms and the treatment package prescribed. The report can be saved on the computer or printed for future references. The ESMMDM is a self sufficient tool and does not depend on any other software in any form. A simple setup program for the ESMMDM expert system is also available.

4.5. Alien expert systems for crop protection

Besides the native expert systems for crop protection, modified versions of several exotic expert systems for crop protection are being used in India. Quite a few successful expert systems for crop protection developed in other countries have been customized according to the Indian conditions and have been introduced in India. Jones et al. [7] have earlier developed a microcomputer-based system to predict primary apple scab infection periods. This system has been now modified as per the Indian climatic conditions and adopted successfully for forecasting primary scab infections in apple orchards in India [8]. Due to the economic importance of the apple crop and the notoriety of the apple scab disease, the Reuter Stokes apple scab predictor is also in use in India [9]. Krause et al. [10] have formerly developed a computerized system, called Blitecast, for forecasting the occurrences of the late blight disease of potato and for scheduling timely application of appropriate fungicides. Using the underlying principles of Blitecast, a decision support system has been developed in India for forecasting the outbreaks of the late blight disease in potato and prescribing suitable fungicides [11].

5. Discussion

Agriculture is still a sector where the level of tacit knowledge remains high [12]. The agricultural expert systems combine the experimental and experiential knowledge with the intuitive reasoning skills of a multitude of specialists to aid farmers and extension workers in making the best decisions for their crops [13]. The agricultural expert systems help in getting instant solution to the problems faced by the farmers. They help the farmers where services of the agricultural experts are not always available and thus solve the problems faced by farmers at remote places. Consequently, the agricultural expert systems reduce the load from the experts. The agricultural expert systems encourage dissemination of research findings and facilitate qualitative research on crop protection. Hence, expert systems can be used as an effective tool for agricultural research and planning.

It has been observed that a computerized expert system is by and far the most efficient extension tool to take the technology from laboratories to farms directly without any dilution of content which normally creeps in because of the number of agencies involved in conventional technology transfer methodologies [3]. This is a salient feature of almost all expert systems and it largely attributes to the popularity of expert systems in numerous domains. Another key advantage of crop protection using computerized expert systems over conventional crop protection techniques is the judicious use of less hazardous chemical pesticides which can help in reducing their ill effects to a large extent [2]. This phenomenon becomes more prominent if a proper coverage analysis of the available pesticides is performed before designing the expert systems.

Moreover, sophisticated expert systems can also estimate potential yield reductions due to the disease occurrences [14]. Thus, the expert systems for crop protection can help the farmers to plan their future moves. Due to all these reasons, the expert systems for crop protection are becoming well accepted in India. As a result, methodical research on the expert systems for crop protection has been started in several universities and research institutes in India. In the near future, these expert systems for crop protection are expected to emerge as an indispensable component of the Indian agriculture.

An interesting fact that can be noted is that most of the agricultural expert systems and more specifically the expert systems for crop protection have been developed by scientists and researchers of reputed universities and institutes instead of any typical software farm. Hence, the quality of treatments prescribed by the expert systems in discussion can be trusted. Most of these expert systems are developed and distributed with purely noncommercial motives.

6. Conclusion

It can be concluded that the advent of expert systems for crop protection has proved to be a boon for the Indian agriculture. If the current trend continues, more expert systems will be available in the coming years and they will cover almost all aspects of Indian agriculture.

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