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Appropriate cultural practices for growing wheat using expert system

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Abstract

Expert System on Wheat Crop Management has been developed by the scientists of IASRI in collaboration with two premier institutions doing research on wheat namely DWR, Karnal and IARI, New Delhi to deliver the package of practices for wheat production to the farmers. The system holds a collection of general principles that are potentially applied to solve a problem related to wheat crop management and extends large information to the wheat-growing farmers. The system works as an information bank for wheat growing farmers that can help them in better crop management in order to enhance productivity and production of wheat in India. The system is available at the URL http://www.iasri.res.in/expert .

Key words : Cultural practices, wheat, expert system, knowledge base, inference engine, user interface.

Wheat (*Triticum aestivum* L. emend. Fiori & Paol.) is the second most important cereal crop in India next to rice. It is the staple food of most of the people of northern, western and central India, where winter is long or medium in duration. India can improve its quantum of production and export sizeable amount of wheat if the production technology is applied and adopted by the farmers with the focus on improving the quality of wheat which is a complex phenomenon influenced by several factors. The most influencing factor, which is in interest of the farmers, is direct saving of money in the form of cost reduction by the proper management of crop.

Crop management decisions require the knowledge of stage-to-stage development and management of the crop. In particular field preparation, sowing methods, fertilizers applications, irrigation scheduling, and application of herbicides, fungicides and growth regulators are important at specific stages of plant growth.

Expert systems have been developed for many kinds of applications in agriculture, involving diagnosis, predictions, consultation and control. Few expert systems have been developed for identifying, managing and controlling insect pest attacks on agricultural crops. There are systems that guide farmers and other stakeholders in irrigation scheduling, fertilizer application for few crops.

Roach *et al*. (1998) developed POMME- an expert system for helping apple growers to manage their orchards. POMME advises growers about when and what to spray on their apples to avoid infestations. The system also provides advice regarding treatment of winter injuries, drought control and multiple insect problems.

Lemmon developed Comax- an expert system that determines the best strategy for irrigating, applying fertilizer, applying defoliants and cotton boll openers. Sensors in the cotton fields automatically report weather conditions to the system, and Comax re-evaluates its recommendations daily (Lemmon, 1986).

The systems already develop did not take a systematic approach that is needed to adopt the right practices. Developing a web based system for the wheat crop in Indian conditions was very much needed to combat the issues of wheat crop being major cereal crop of the country. Efficiency could be brought into the crop production system by integrating and disseminating the knowledge and information available on the standard practices on wheat crop through expert system (ES) to the farmers so that they could have right information at right time to plan their operations and take decisions.

An ES on wheat crop management has been developed by the scientists of IASRI in collaboration with two premier institutions doing research on wheat namely; DWR, Karnal and IARI, New Delhi. The system carries a complete package of practices including the field preparation, sowing time, seed rate, method of sowing, irrigation scheduling, fertilizer requirement and weed control that have been standardized (Islam *et al*., 2012).

Materials and Methods

The system is composed of a knowledge base, user's interface and an inference engine. The knowledge base contains the collective diagnostic expertise encoded in the form of IF-THEN rules of interviewed specialists in agronomy. It has a three tier architecture in which the front end of the system and interfaces has been developed using standard web technology. The database designing for the system has been done using MS Access due to the ease of handling the queries and easy management of information, facts and information retrieval. The inference engine performs the reasoning and problem-solving tasks including searching the knowledge base for applicable rules while directing questions and issuing diagnostic reports to the user. The inference engine and inference drawing mechanism was developed in the integrated development environment provided by Microsoft Visual Studio.

Expert System Architecture

An ES is an artificial intelligence application that uses knowledge of human expertise to aid in solving problems. The degree of solving farmer's problem is based on the quality of data and rules obtained from the wheat expert. Expert systems are designed to perform at a human expert level. The architecture of the system is depicted below in Fig. 1. The user presents the problem to the system through the user's interface that brings the solution retrieving from the knowledge base and applying the inference mechanism. The system has another interface for the experts/knowledge engineers to add/modify inference rules (Islam *et al*., 2007).

Knowledge Base

The part of the expert system that stores the knowledge is called the knowledge base. It is the integration of knowledge collected from the domain experts and facts about the domain. The facts about the domain are put into databases and facts collected from the experts will be in form of rules.

This system contains both kinds of knowledge, factual and heuristic. Factual knowledge is that knowledge of the task domain that is widely shared, typically found in textbooks or journals, and commonly agreed upon by those knowledgeable in the particular field. Heuristic knowledge is the less rigorous, more experiential, more judgmental knowledge of performance. It is the knowledge of good practice, good judgment and plausible reasoning in the field. Knowledge allows interpreting the information in the databases to diagnose, design, and analyze the problem.

The most important ingredient in any ES is knowledge. The power of ES resides in the specific, high-quality knowledge they contain about task domains. All Researchers will continue to explore and add to the current repertoire of knowledge representation and reasoning methods. But in knowledge resides the power. Because of the importance of knowledge in ES and because the current knowledge acquisition method is slow and tedious, much of the future of ES depends on breaking the knowledge acquisition bottleneck and in codifying and representing a large knowledge infrastructure.

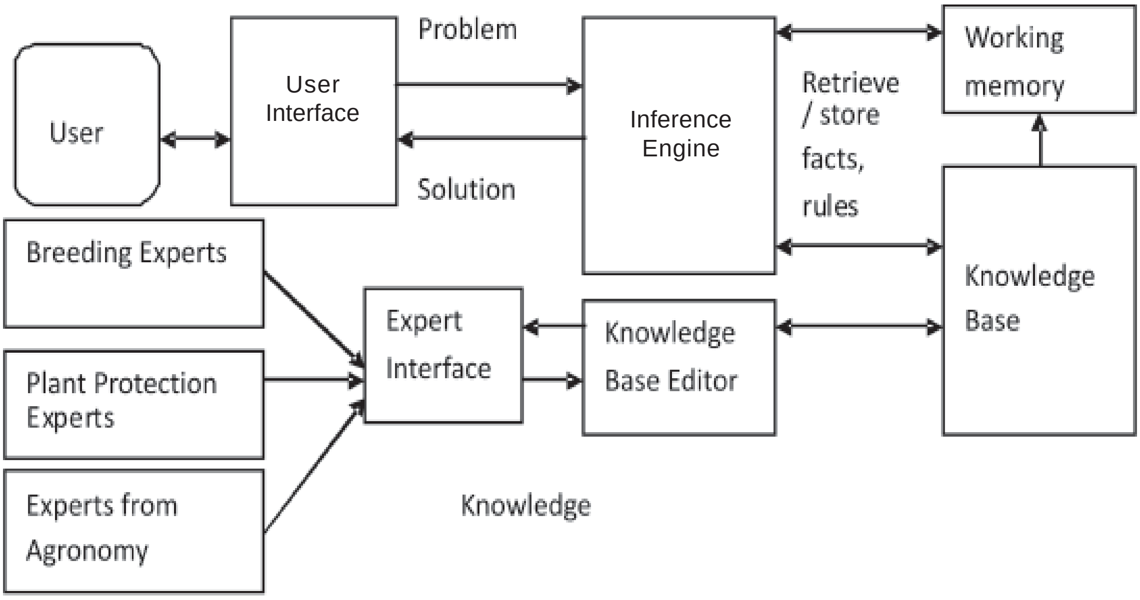

Fig. 1. Expert system architecture

The Inference Engine

The real force of ES is their capacity to make inferences or the drawing of conclusions from premises. This is precisely what makes an ES intelligent. Even when it is possible to represent domain knowledge as rules, a human expert would not only have to know how to apply these rules but in which order they should be applied to solve a particular problem. Similarly, a computer ES would need to decide which, and in what order, the rules should be selected for evaluation. To do this, an ES uses an inference engine. This is a program that interprets the rules in the knowledge base in order to draw conclusions. Two alternative strategies are available: backward chaining and forward chaining. A particular inference engine may adopt either or both.

Rules for fertlizer application

The inference procedure is carried out in three phases
Location → Select (sowing condition) → Select (Sowing Time) → (Execute)

For inorganic fertilizer application

IF Location is (State/Zone options)
and Sowing condition is (Options of Sowing Condition e.g. irrigated, semi irrigated, rainfed…..)
and the sowing time is (options of sowing time e.g timely sown, early sown, late sown, …)
then the fertilizer doses is (combination of fertilizer doses…..)

Rules for sowing technology

Rules has been framed for sowing technology. Sowing technology that has been taken into consideration are sowing time, seed treatment, line spacing, depth of sowing and seed rate.

Location → Select (sowing condition) → Select (Sowing Time) → (Execute)

Rules for sowing time

IF Location is (State/Zone options)
and Sowing condition is (Options of Sowing Condition e.g. irrigated, semi irrigated, rainfed…..)

and the sowing time is (options of sowing time e.g timely sown, early sown, late sown, …)

then the sowing date is (combination of appropriate sowing dates…..)

The engine has been developed using ASP framework provides by Microsoft. The Active

Server Pages (ASP) technology, a technology made available by Internet Information Server (IIS). ASP is a powerful tool for making dynamic and interactive Web pages. These are web pages that contain scripting statements executed by the Web server. The output of the scripting statements will be merged with the static parts of the page, and delivered to the browser as the response to the HTTP request initiated by the Web browser. Active Server Pages (ASP) technology is language-independent. Two of the most common scripting languages are supported right out of the box: VBScript® and Jscript.

User interface

The user interacts with the system through a user interface which uses closed type of questions. Small tips of descriptions about the question were made to recognize without effort. Images are shown in certain circumstances, so that the user can understand the query. A friendly interface enables inexperienced users to specify problems for the system to solve and to understand the system's conclusions.

Knowledge base editor

Knowledge base editor helps the expert or knowledge engineer to easily update and check the knowledge base. Its user friendliness gives the expert a power to update and add new information. In the developed system almost every information can be updated as per the requirement.

Results and Discussions

The agronomic aspect of the system helps a user to adopt right cultural practices for wheat crop. The system helps him right from field preparation to proper management of the crop. The Cultural practices module broadly provides information on four aspects. This shows you options for 'Nutrient Management', 'Sowing

Fig. 2. Home page of expert system

Fig. 3. Home page of cultural aspects

Technology', 'Tillage Technology' and 'Water Management' aspects as shown in 'Various Cultural Aspects' (Fig. 4.).

For nutrient management system covers application of inorganic fertilizer, farm yard manure, green manure and Integrated Nutrient

Fig. 4. Page showing option on cultural aspects

Fig. 5. Page showing option on nutrient management

Management based on location, environmental condition, soil condition, sowing condition and time, etc. The system guides a user on tillage technology like field preparation with tractor or plough, zero tillage, FIRB based on various field and environmental conditions. The system helps in choosing the right sowing technology which is economic and gives better return that includes seed rate depending on the size of the seed and condition, sowing depth, spacing between the rows and right method for a particular condition. The system guides in irrigation scheduling like time of irrigation based on field location, time of sowing and field conditions. It also helps in scheduling the irrigation based on the resources available with the farmer.

Input forms had been developed for asking the questions to the farmers that would be in a specific order according to the questionnaire. The system analyses the input from the farmers in the perspective of the query and provides the result with appropriate degree of confidence. Inferences are drawn on the basis of data supplied by the farmer, using system knowledge base.

The system gives a procedural approach to get new knowledge, rules and heuristics for cultural practices. It gives an opportunity for continuous refinement of the existing knowledge on new aspects or new technology on wheat. This again gives the prospect of providing latest knowledge to the farmers on agronomic practices. It will help in reaching out the information to the user and help in management of information. The system is available on the web (http://www.iasri.res.in/) with a link for Wheat ES providing global access to the users.

From the homepage of the website, cultural aspects can be accessed (Fig. 2). The system provides information on nutrient management. It guides the user on application of inorganic fertilizer, green manure, FYM and Integrated nutrient management. The system provides on the basis of location, field and sowing condition. The process has been depicted as in Figs. 3-6.

The system helps in getting information on sowing time based on location and sowing conditions. It has been shown in Figs. 7-10 gives information on sowing methods.

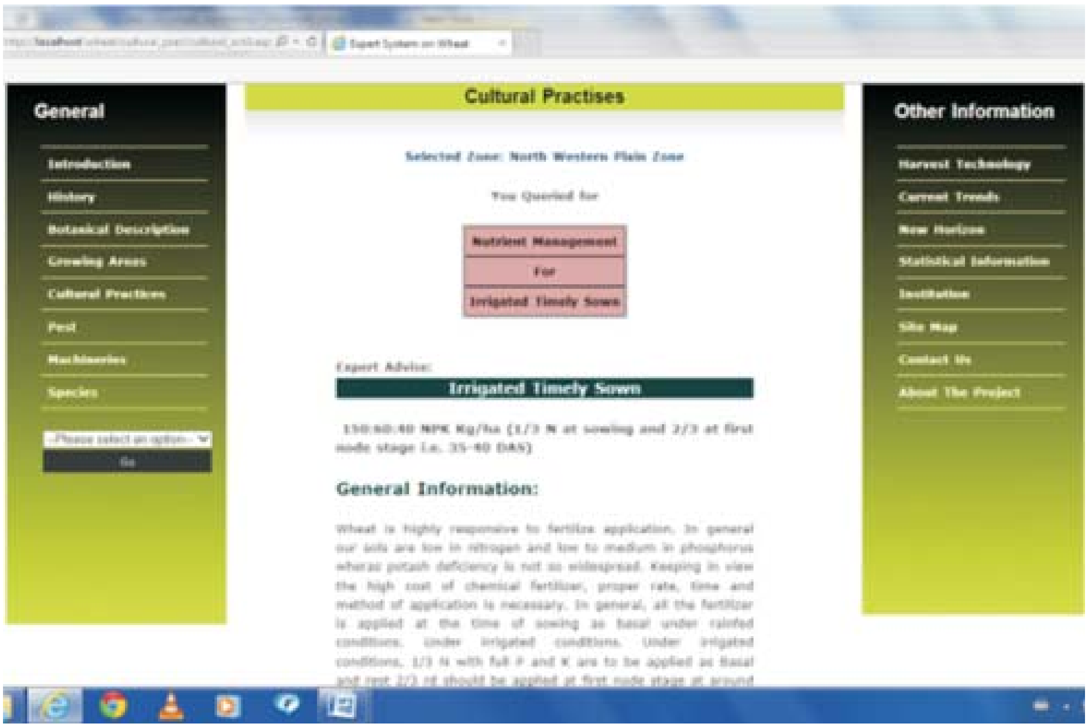

Fig. 6. Page showing details of Inorganic Fertilizer

Fig. 7. Getting information on sowing technology

Fig. 8. Form for getting information on sowing time

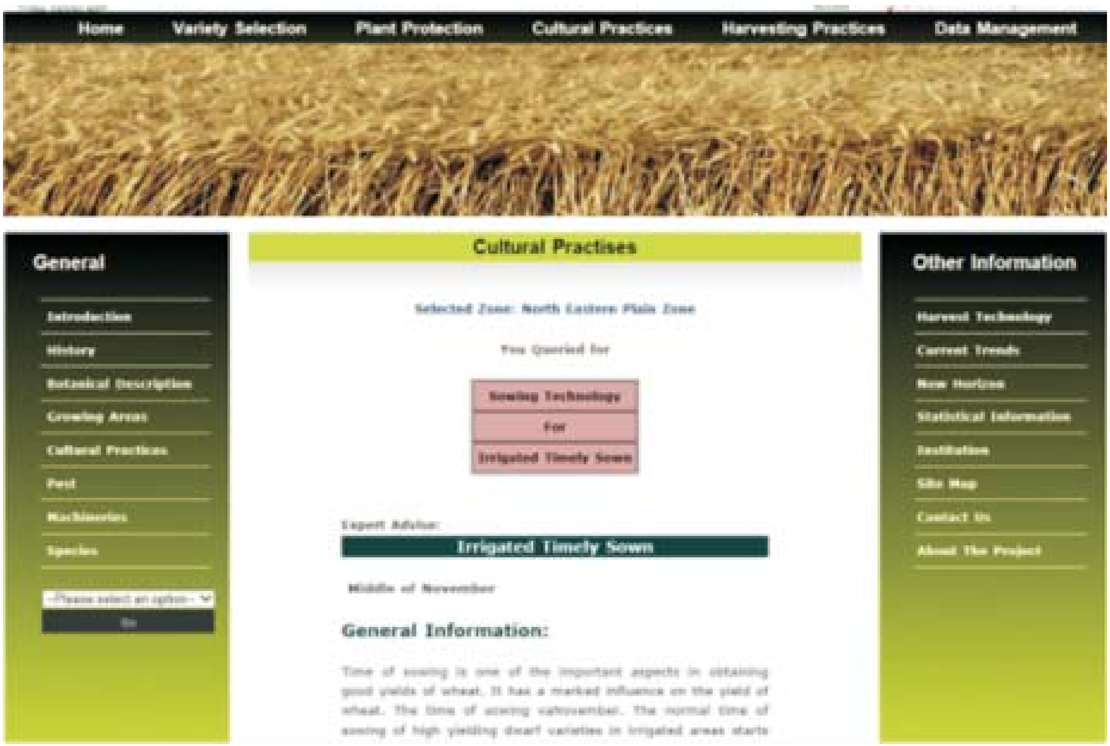

Fig. 9. Information based on user's query

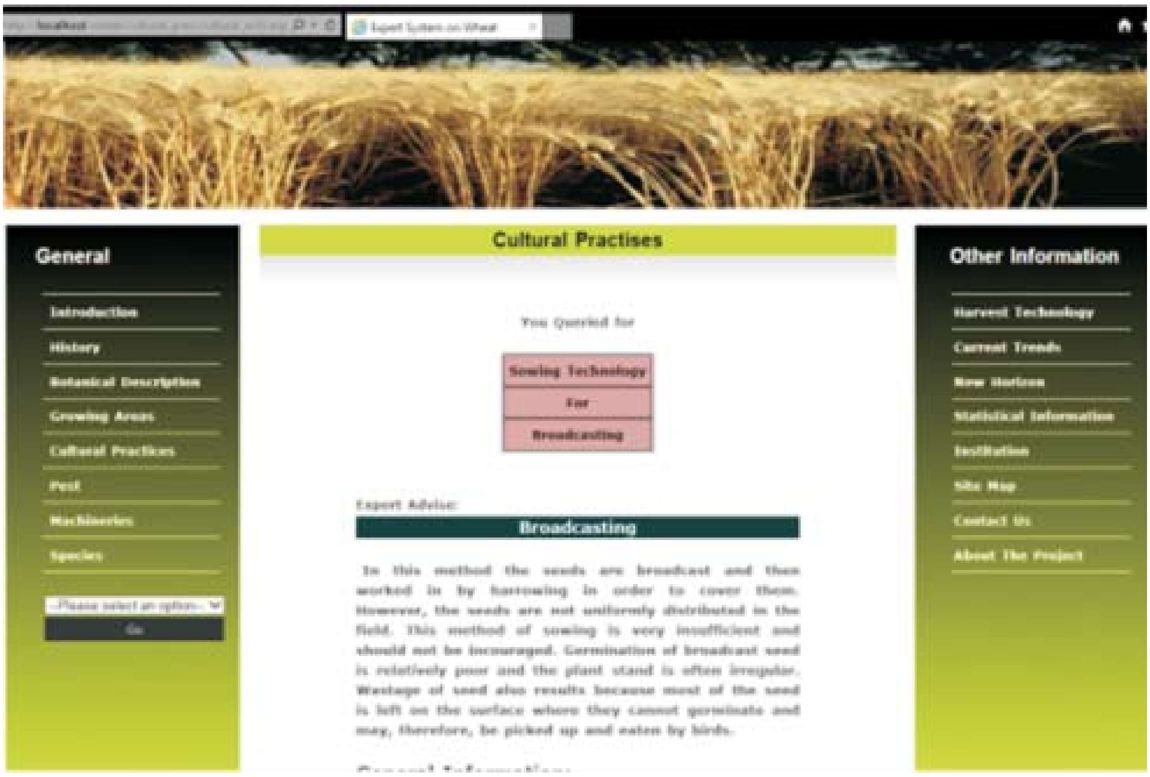

Fig. 10. Information on sowing method

The system carries a number of practices stored in its knowledge base that includes field preparation, sowing technology, irrigation scheduling, new technologies like FIRB and Zero Tillage. The system is scalable and has the facility of having new information on any technology adopted. The information about existing practices has been scientifically organized and can be entered in the system through a user-friendly interface. The system has been designed in such a way, that an expert can enter or modify the rules and information directly to the system.

Conclusion

In agriculture, Expert Systems can be used for extending the research to farmers and it can work as a problem-solving tool for them. These systems on Agriculture could have a powerful mechanism with extensive potential to solve the problems. The Agriculture Expert Systems are designed to emulate the logic and reasoning processes that an Expert would use to solve a problem. These systems are based on the integration of knowledge and experience of specialists from different fields and have the capability to answer relevant questions and explain its reasoning process.

The ES on Wheat Crop Management is an example of knowledge-based system that has organized a large amount of information on wheat crop management. The system has organized the information on varieties, disease, insects and cultural practices. It also carries information on wheat machineries that are used for different operations. Such systems can also be developed on other crops and other disciplines of agriculture. This system holds bulk of information generated by DWR, Karnal and IARI, New Delhi. The system gives a procedural approach to get new knowledge, rules and heuristics. It gives an opportunity for continuous refinement of the existing knowledge in the system. The system's cultural practices module will help famers to schedule their plan in scientific way and get better harvest and economic returns.

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