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Journal of the Indian Society of Agricultural Statistics 72(3) 2018 255–259

Diagnosing Wheat Disease using Expert System

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Received 15 April 2017; Revised 12 October 2018; Accepted 17 October 2018

SUMMARY

Plant protection is one of the major components of crop management process. Crops are under threat of insects and diseases attack from the day they are seeded to the day they are harvested causing a substantial damage to the crop yield that affects adversely to the farmer's economy. Many factors influence disease development and its intensity in plants, including hybrid/variety genetics, plant growth stage at the time of infection, weather (e.g., temperature, rain, wind, hail, etc.). Wheat (*Triticumaestivum* L. emend Fiori &Paol.) is an important crop affected by various diseases at different stages. Diagnosing the disease and its management is very important to save the crop from major damages. An Expert System on Wheat Crop Management (Exowhem) has been developed by the Division of Computer Application, ICAR-IASRI, New Delhi in collaboration with ICAR-IARI, New Delhi and ICAR-IIWBR, Karnal that helps in diagnosing the diseases and helps in its management. The system carries information about 14 important diseases affecting wheat crop stored in its knowledge base. 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/wheat.

Keywords: Wheat, Disease diagnostic system, Expert system, Artificial intelligence.

1. INTRODUCTION

Plant protection is one of major components of crop management. A farmer needs to protect his crop from diseases, weeds and insects. This is true for all crop species and production systems. Wheat (Triticumaestivum L. emend. Fiori & Paol.) is an important crop affected by various diseases at different stages. One of the major constraints in boosting up the wheat production is the prevalence of a number of fungal diseases. Among the major diseases of wheat, important ones are three rusts (stem, leaf and stripe), loose smut, flag smut, Karnal bunt, hill bunt, foliar blight and powdery mildew (Joshi *et al.* 1986). Diagnosing the disease and its management is very important to save the crop from major damage. An Expert System on Wheat Crop Management (Exowhem) has been developed by the Division of Computer Application, ICAR-IASRI, New Delhi in collaboration with ICAR-IARI, New Delhi and ICAR-IIWBR, Karnal that helps in diagnosing the diseases and helps in its management.

Expert systems have been developed for many kinds of applications in agriculture, involving diagnosis, predictions, consultation, control, etc. (Gonzalez-Andujar, 2006; Knight, 1997 and Pau and Carrascal, 1992). A web-based interactive system for risk management of potato late blight has been developed to help potato growers in making important decisions on optimal use and timing of fungicide applications to mitigate the risk of potato late blight (PLB) disease development (Wharton *et al.* 2008).

Puls Expert, an expert system for the diagnosis and control of diseases in major pulse crops has been developed (Devraj and Jain, 2011). An expert system has been developed for tomato diseases identification

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(Yialouris *et al.* 1997) with limited information. Only few expert systems have been reported for disease diagnosis (e.g. Gonzalez-Andújar *et al.* 2006).

The knowledge of domain experts, processing of natural language texts, and information available in literature are the primary resources for extracting knowledge in developing expert systems. The extraction of vast knowledge available in these formats/ forms requires the development of software agents that run a sequence of action on behalf of a human or another agent independently (Duan *et al.* 2012). Further, the multi-agent system can be developed for building expert systems (Kadhim *et al.* 2016).

Many of these systems do not take stage wise diagnostic approach and are mainly PC based. Developing a web based system for diagnosing wheat diseases in Indian conditions is 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 diseases of wheat crop through ES to the farmers so that they could have right information at right time, to plan their operations and take decisions.

This paper discusses the developed expert system on wheat crop to provide farmers and technicians the information for diagnosing diseases that come at various stages of the crop. Exowhem is a web based system that is accessible globally through the internet and works on the user's query.

2. MATERIALS AND METHODS

The transformation of problem-solving expertise from a knowledge source to a program is the heart of the expert-system development process. Acquiring knowledge was found to be the major bottleneck in developing the expert system. One of the important areas of knowledge management is knowledge acquisition and representation. Knowledge engineers have little awareness about the domain and specialists are limited and occupied. The knowledge engineering methodologies for building Exowhem have applied knowledge acquisition techniques (e.g. interviewing, protocol analysis, personal construct theory, card sorting, literature etc.) for eliciting the tacit knowledge from domain experts.

As a part of the technical programme for the development of "Expert System on Wheat Crop Management", knowledge engineers were allotted different modules. They acquired published information on the subject, ideal conditions for the spread of a disease, affected plant part and symptoms that appear. A series of questionnaires were developed to interview the specialists. Several group meetings and workshops were also organized to consult the experts to validate the rules. Rules on disease identification were framed in a workshop and were further refined in consultation with plant pathologists. Some practical approach of disease identification was also discussed with experts leading the knowledge engineers to utilize the heuristics that the experts use in some special situation. The knowledge so acquired from experts was stored in the knowledge base. It also contained the collective diagnostic expertise (often encoded in the form of IF-THEN rules) of interviewed specialists in their relevant domain area. The knowledge typically comes from a series of conversations between the developer of the expert system and one or more domain experts. The complete acquisition process applies the knowledge to solve the problems specified by the domain experts. The system applies its stored knowledge to solve the problem (Islam *et al.,* 2012).

Many factors influence disease development and its intensity in plants, including hybrid/variety genetics, plant growth stage at the time of infection, weather conditions (e.g., temperature, rain, wind, hail, etc.), single versus mixed infections, and genetics of the pathogen populations. Variation inherent in these factors often makes disease prediction and diagnosis difficult at the early stages of disease on individual plants as well as at the early stages of an epidemic. However, many disease symptoms do become diagnostic at some stage of disease development and a reasonable level of confidence can be placed in diagnosis based on these symptoms. Considering all these factors a mechanism for identifying the disease affecting the crop has been developed.

A wheat plant grows in stages and at each stage, new plant part emerges. These parts are vulnerable to disease attacks caused by some pathogens that grow in an environment suitable for them. In a suitable environment two or more diseases attack the plant at the same time. These diseases have some major symptoms that might be common. The disease may be

identified through some minor symptoms associated with major symptoms. These symptoms are associated with some colours as every disease affects the plant or its part in a different way. This process has been summarized in Fig. 1.

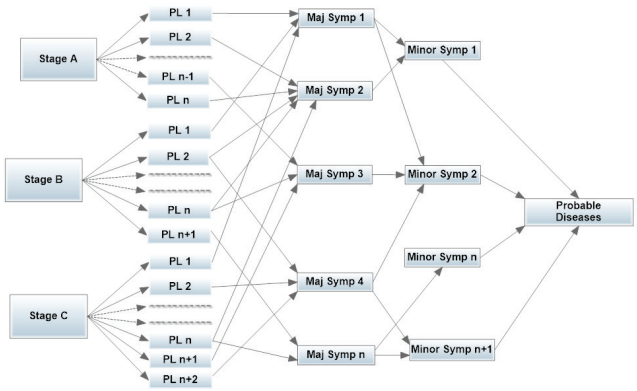

Fig. 1. Disease Diagnostic Mechanism

This knowledge has been obtained from the experts by group meeting of knowledge engineers and domain experts in different sessions. This knowledge is refined further in different sessions and encoded in the form of rules (Islam *et al.,* 2007).

Disease Table (Table 1) states the antecedent and consequent of rules.

Table 1. Disease Diagnosis Rule Table

GOAL Consequent	CONDITIONS Antecedent				
	STAGES OF PLANT (ANY ONE STAGE)	PLANT PART AFFECTED	MAJOR SYMPTOM	MINOR SYMPTOM	COLOR (ANY ONE COLOR)
Leaf Rust	• Tillering • Stem Extension • Heading Stage	• Leaf • Leaf Sheath	Pustules / Spots	• Rusty • Pustules circular in shape • Pin head size • Pustules Scattered • Light brown when rubbed with finger	• Orange / light brown • Spot turns black at maturity
Stem Rust (Black Rust)	• Stem Extension • Heading Stage	• Leaf • Leaf Sheath • Stem • Spikes	Pustules / Spots	• Pustules / Spots Ragged or torn • Scattered • Sites feel rough to touch • Dark brown when rubbed with finger	• Dark reddish brown • Spot turns black at maturity
Stripe Rust (Yellow Rust)	• Tillering • Stem Extension • Heading Stage	• Leaf • Leaf sheath • Spike • Awn	Stripes formed parallel to veins	• Yellow stripes formed on leaves • Yellow powder on finger touch	• Yellow to orange • Black
Powdery Mildew	• Tillering • Stem Extension • Heading Stage	• Leaf • Leaf Sheath • Earhead • Awns	Powdery growth	• Powdery colonies appears • Grayish white powder after shaking	• Grayish-White
Flag Smut	• Stem Extension • Heading Stage	• Leaf • Leaf Sheath	Stripes formed parallel to veins	• Black stripes • Leaves droops like a flag	• Black in color
Karnal Bunt	• Heading Stage	• Earhead	Awns spread and Earhead gives fishy odour	• Grains partially infected • Grains filled with black powdery mass	• Black powdery mass
Common Bunt	• Heading Stage	• Grain • Earhead	Grains give fishy odour	• Grains fully infected • Kernel are same size and shape • Slight reduction in plant height	• Black
Loose Smut	• Heading Stage	• Earhead	Grains converted into black powdery mass	• No grain formation • Powdery mass blown away by wind • Rachis and remnants remains	• Black

The consequent denotes goal/result of the rule. The antecedents are the conditions, which have been used to identify the goal. To attain the goal, equal importance must be given to each condition. Rules are designed for diagnosing diseases that are prevalent in Indian condition. On the basis of these rules, the attributes, tables and relations have been established in Microsoft Access. These rules have been stored in the knowledge base and implemented in relational database to provide the server side interaction through the development of Microsoft based Active Server Pages (ASP) technologies. The data base for plant protection module includes the table and fields for disease diagnosis and their corresponding treatment to manage the identified disease. The relationships established in database are shown in Fig 2.

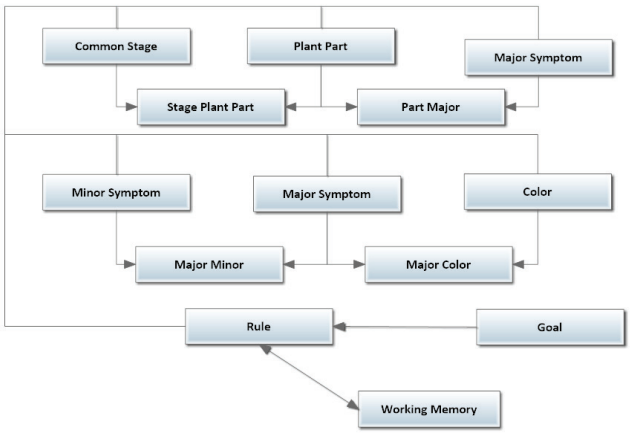

Fig. 2. Relationship between the tables in Plant Protection

The system uses web based technology and can be accessed through any web browser. The inference engine of the system has been developed using VBScript and Java Script by utilizing Microsoft Visual Studio, an Integrated Development Environment.

The inference procedure is carried out in three phases

Select (Stage, Symptom)

Identify (Color)

Match (Possible Images of different disease)

Execute (To know the actual disease)

During the match stage the contents of working memory is compared with the facts and rules stored in the knowledge base. When consistent matches based on major and minor symptoms are found, the rules are again compared on the basis of color and selection of the image help in diagnosing one of the probable diseases affecting the crop. This will also show the certainty (in percentage) of the diagnosed disease.

3. RESULTS AND DISCUSSIONS

The system has been developed for wheat growing farmers and can be used by wheat experts. The user submits a problem through the interface to the system. The system generates a series of questions and takes the input from the user.

The system is available on the web (http://www.iasri.res.in/) with a link for Wheat Expert System providing global access (http://www.iasri.res.in/wheat) to the users as in Fig. 3. The system interacts with the user in a user friendly manner, queries based on plant part affected (Fig. 4), stage at which symptoms appear, other minor symptoms such as color of the affected part, pustules formation (Fig. 5) etc. are posed to the user in the form of input forms. Based on the answers or inputs provided by the user, the system shortlists the most probable disease with which the crop may be infected (Fig. 6). The system then further displays pictures of these shortlisted diseases and confirms from the user whether any of the displayed picture matches with infected part of the plant. The inference engine accepts these dialogues and uses this dynamic information together with the existing knowledge on diagnosed wheat disease, its characteristics, symptoms, pathogens, conditions etc. as in Fig. 7. The contents of the knowledge base are used to derive conclusion. On the confirmation by the user, the system identifies the disease with which the crop is infected along with the probability for the incidence of that particular disease. The system then suggests the required treatment and control measures for the diagnosed disease.

Fig. 3. Home Page of Wheat Expert System

Fig. 4 Displaying Plant Part

Fig. 5. Displaying Minor Symptoms

The system gives a procedural approach to get new knowledge, rules and heuristics for crop protection. It gives an opportunity for continuous refinement of the existing knowledge on diseases and insects of wheat. This again gives the prospect of providing latest knowledge to the farmers to save his crop from the disease infection. It helps in reaching out the information to the user and help in management of their crop.

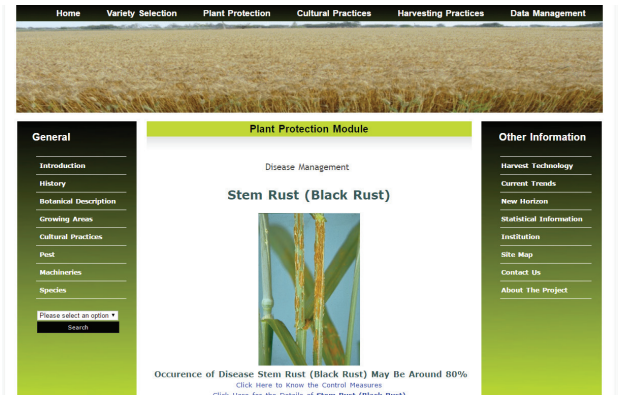

Fig. 6. Displaying Identified Disease

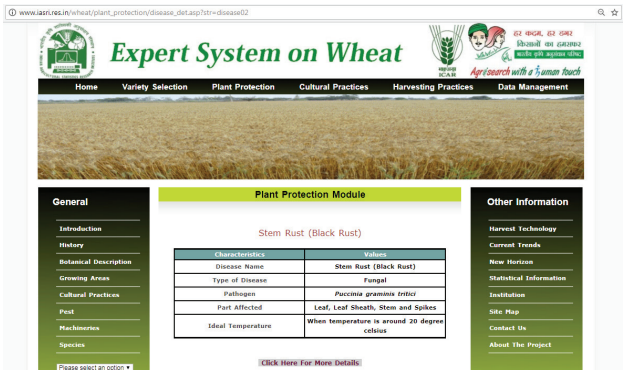

Fig. 7. Detail Description of the Disease

Exowhem has a Knowledge base of disease symptoms and diagnostic mechanism in it. It has the rules that plant pathologist use to make the diagnosis of wheat disease. The admin has the capability of adding new rules, modify the existing rules or delete one if it is found incorrect. The system is also accessible through web browser in any mobile device which supports the mobility of the system.

4. CONCLUSION

Expert Systems are few of the most vital components of Information and Communication Technology. The biggest advantage of such systems is that all the new knowledge/technology created about the domain can reach farmers through extension officers without much effort. The farmers could get information by the click of a button. This system can be taken up as a model and can be easily replicated for other crops. Through the use of advances in Information Communication Technology, the system has the capability to integrate it with other variables which will definitely help in fulfilling our needs to strengthen our Agriculture Research System. It is the need of the hour that we should contribute to agriculture by adopting new technology that can enhance the mechanism of extension.

ACKNOWLEDGEMENTS

We are thankful to Director(s)of the institute(s)for taking personal interest in the project and providing valuable guidance in developing the system. We are also grateful to Digital Empowerment Foundation for recognizing the project and honouring it with 'Manthan Award South Asia' for the best e-content.

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