Progressive Horticulture, Vol. 47, No. 3, Dec. 2015

DOI : 10.5958/2249-5258.2015.00079.2

An expert system for mango (*Mangifera indica* L.) disease diagnosis and management

H.C. Verma[1]; P.K. Shukla[2]; B.K. Pandey[3] and A.K. Misra[4]

ICAR-Central Institute for Subtropical Horticulture, Rehmankhera, Lucknow – 226101 (UP), India

ABSTRACT

This paper describes the development of a rule-based expert system for the diagnosis of diseases of Indian mango and to suggest the appropriate management. It follows an object oriented approach of presenting rules in the knowledgebase of expert system in the form of Object-Attribute-Value that allows developing knowledge base without using expert system shell software. Initially this system is developed for five major diseases (powdery mildew, anthracnose, bacterial canker, phoma blight and red rust), which may further be extended to different diseases of mango. This expert system is devised to show typical symptoms of the disease, weather parameters critical for rapid development of the diseases and suitable integrated disease management measures. After diagnosis, it also advises the management options of the different diseases. Expert system also include weather based forewarning of powdery mildew disease, which takes into account three weather parameters i.e., maximum and minimum temperatures, relative humidity and wind speed to find out whether weather is conducive for development of powdery mildew or not? If weather parameters are favourable, then the system advises its management options. It is good enough for providing appropriate advice for early diagnosis and integrated management of diseases for enhancing mango productivity. It would be helpful in early and accurate identification of diseases and their management by the application of biological, cultural, physical and chemical management methods. The system would serve as an effective knowledge dissemination tool and would empower orchardist for effective decision making for the timely management of the different mango diseases.

KEY WORDS: Expert system; Mango; knowledgebase; disease diagnosis; management of disease.

India ranks first among mango producing countries accounting for about 50 per cent of the world's mango production. The crop is affected by large number of diseases at all stages of its growth (Ploetz and Prakash, 1997). On an average, the crop suffers 10-15 per cent yield loss due to different diseases. One way to increase mango production and improve its quality is to reduce losses caused by these diseases. Identification of problems related to mango health and the implementation of control measures is therefore important. If diseases are not identified correctly or control measures are not adopted at right time, the loss may reach up to 90 per cent (Schoeman *et al.*, 1995). Keeping in view the limitations of mango growers in diagnosis of the different diseases and timely decision for the management of the different diseases, an expert system for diagnosis and integrated management of major diseases of mango has been developed at CISH, Lucknow.

The expert system is a computer program that uses artificial intelligence to solve problems within a specialized domain that ordinarily requires human expertise. It uses non-numerical domain-specific knowledge to solve problems with a competence comparable with that of human experts. The Expert System also called the Knowledge Based System is a tool for information generation from knowledge. 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.

There are many benefits of an expert system over human expertise. The knowledge contained in expert system is permanent, transferable, consistent and affordable while knowledge of human expert is perishable, difficult to transfer, unpredictable and expensive, respectively.

[1]**Corresponding Author**, email: vermahc@hotmail.com, Scientist SS (Computer Application);

[2]**Senior Scientist** (Plant Pathology);

[3]**Principal Scientist** (Plant Pathology), SMD, Horticultural Science Division, ICAR, New Delhi;

[4]**Head**, Division of Crop Protection

In an organization the source of competitive advantage lies not in the knowledge but application of knowledge. The knowledge application system such as expert system, facilitates the transfer of knowledge between various communities of practice (Man Singh *et al.*, 2007)

This paper describes the development of a rule-based expert system for the diagnosis of diseases of mango and to suggest the appropriate treatments/management./ control guide-lines. The system can be used as a diagnostic tool by orchardists and for educational and extension purposes in mango pathology. It provides a diagnosis based on the description of the external appearance or behaviour of the affected tree. Corresponding pictures accompany the most important symptoms and certain measures to be taken are proposed (Mahaman, *et. al.*, 2002.). The system provides support to improve the decision-making ability of orchardists, extension workers, researchers, managers, trainers, etc.

MATERIALS AND METHODS

An object oriented approach was used for presenting rules in knowledgebase of expert system in form of Object-Attribute-Value (O-A-V) that allows developing knowledge base without the need of costly expert system shell software (Yialouris and Sideridis, 1996.). The following standard steps were followed for development of expert system software:

i) Knowledge acquisition: It involves acquiring heuristic and factual knowledge pertaining to particular domain from different sources.The reliability of diagnostic expert system depends on the quantity and quality of knowledge that it handles, i.e. the number of diseases it can diagnose and the appropriate representation of the domain expert knowledge. This can be achieved by the knowledge engineer with a knowledge acquisition procedure. Knowledge acquisition is the most critical and problematic phase in the expert system development (Yialouris and Sideridis, 1996). Knowledge acquisition though critical, has always been the bottle neck in developing expert system (Gaines, 1987).

Although an expert system aims to act as human reasoning process giving the same advice and making the same decisions as a human expert (Huirne and Dijkhuizen, 1992), there is a fear that the computer is going to replace the expert (Kahney, 1989; Nitsch, 1991). During the knowledge acquisition procedure, particular attention was paid to the accuracy of description of the symptoms and related problems associated with the main mango diseases.

ii) Knowledge representation (KR): A knowledg base (KB) contains the domain knowledge required f solving a specific problem. The knowledge base represented in the form of rule base in our system (Harm and King, 1985). The symptoms of different crop diseas are represented as object–attribute–value (O–A–V) as giv in Tables. 1-2 (Yialouris and Sideridis, 1996). The KB internally represented in tabular form as a relation database using MS® Access 2007 *. Each condition o rule can be a simple sentence which is true or false, or O-A-V triplet.

The knowledge base contains expert's knowledge the given domain. The knowledge is represented in t linguistic form of IF-THEN rules (Table.3). Althou different KR methodologies exist such as rules, fram semantics nets, etc. but rule-based knowled representation is the most commonly used methodolo for developing agricultural expert systems.

However, for developing a robust expert syst comprised with IF-THEN rule based logical models w used as the conventional expert system developm technique was not sufficient.

One of the most important design considerati behind this expert system was to provide the best us friendliness. So we tried to keep graphical user interf simplest. The startup screen of expert system is presen

Table 1: Approaches: Rule-based table of relati between symptoms and diseases

Mango diseases	Powdery mildew	
Spot	Appears on	Lower surface of leaf
	Has colour	White
	Has shape	irregular
	Symptom	White powdery growth

Table 2: Object-Attribute-Value form of knowl representation

Disease Name	CANKER
The canker has colour	brown to black
The canker has shape	irregular
The canker is type of	Necrotic
Appearson	Leaves
Disease Name	Anthracnose
Appears on	Leaves (younger)
The Disease has colour	brown to black
The Disease has shape	regular (circular)
The Disease is type of	non-Necrotic

in Fig.1. The knowledge base consists of simple IF-THEN rules in form of forward chaining i.e. effect-to-cause (Table. 3).

The Mango Expert System was implemented from production rules (i.e., IF <effects >

THEN< causes >; LAI Jun-chen, *et. al.*, 2010; Fig. 3).e.g.

IF spot has 'colour white' THEN

Disease is 'Powdery Mildew'

Table 3: An example of knowledgebase rule to diagnose powdery mildew disease

Rule 1.
IF spot appears on 'lower surface of leaves'
AND spot has 'colour white'
AND spot has shape 'irregular'
AND spot has 'white powdery growth'
THEN disease is "Powdery mildew"

iii) **User Interface:** The interaction between the system and the user was kept as simple as possible. The Expert System provides the user, at the beginning of the consultation mode, the options to confirm or reject some of the very common symptoms. First of all, the user finds out the infected part.

Fig 1. The startup page of expert system for mango

of the plant and the type of infection (**Fig.**2), If the type of infection has a very common symptom, such as a spot, the system prompts the user to determine the special characteristics of the spot (**Fig.**3) e.g. the colour and shape of spot. After supplying the system with this initial information, the system applies the data to the knowledge base and, asking for supplemental data from the user, tries to make a diagnosis. If the system diagnoses one or more diseases, it then provides option to display the management/control/treatment guide-lines (**Fig.**5).

Fig 2. The screen depicting optionsforPowdery mildew diagnosis

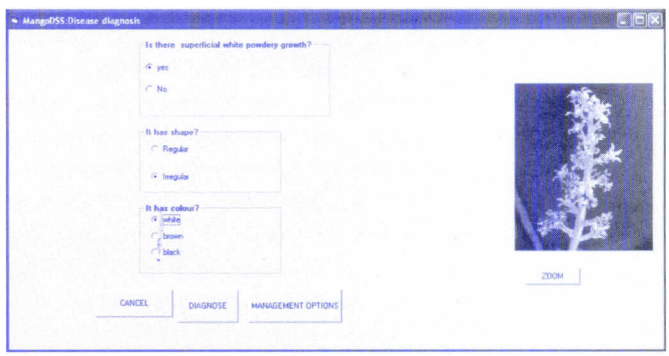

Fig 3. The screen for selecting options for diagnosis of Powdery mildew

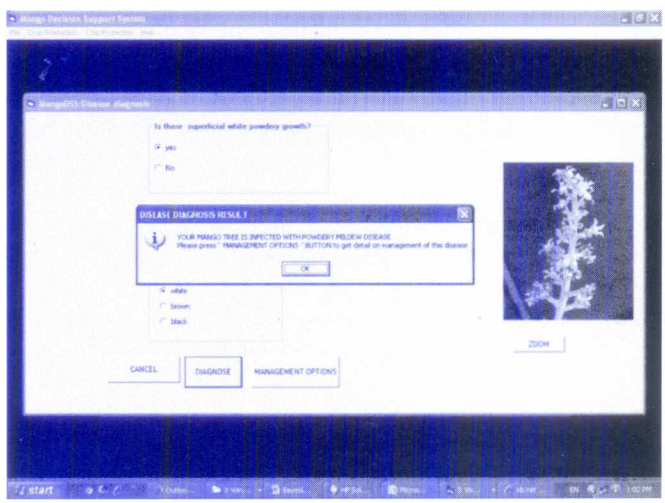

Fig 4. The screen showing diagnosed disease

Fig 5. The screen showing management options for powdery mildew.

The expert system also has a module for diagnosis of Anthracnose disease of mango. A user can start diagnosis by initiating a question and answer session (**Fig**.6). First system asks about the part of the tree affected and provides multiple options to the user for selection of best suiting option. Once user selects the correct option, the system proceeds with more specific options/questions e.g. spots shape and colour. It also has multiple images of diseased part of tree to ensure more accuracy of diagnosis (**Fig**.7). It also makes diagnosis easier. Once diagnosis was completed, the system generates disease control/ management guide-lines (**Fig**.9).

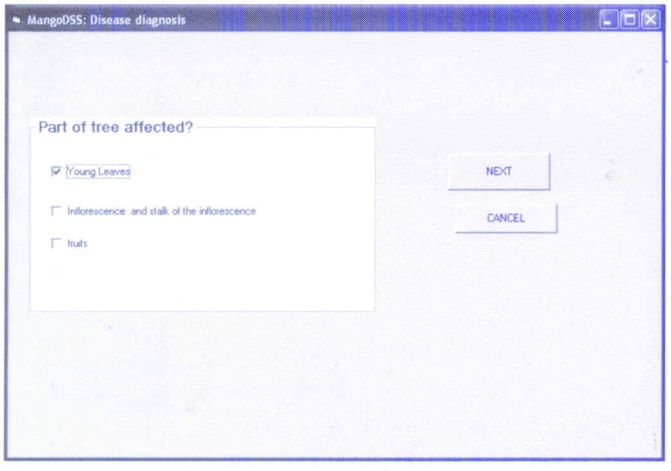

Fig 6. The startup screen for diagnosis of Anthracnose

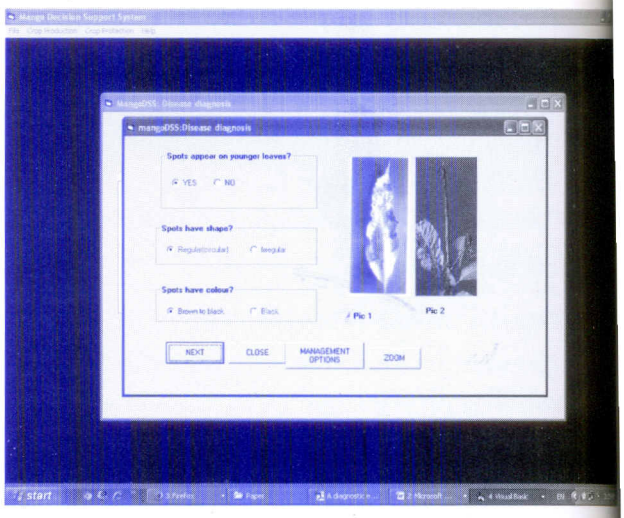

Fig 7. The screen showing the diagnosis options for Anthracnose

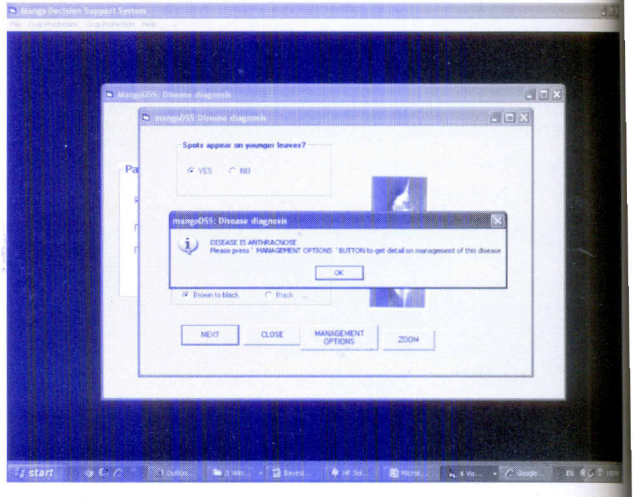

Fig 8. The screen with diagnosed disease i.e. anthracnose

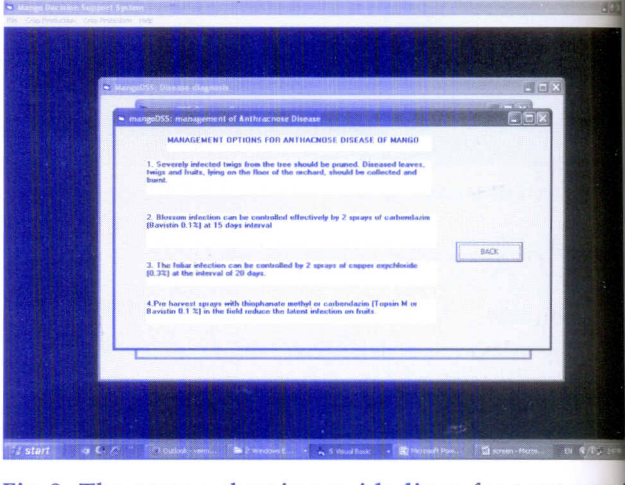

Fig 9. The screen showing guide-lines for treatment of diagnosed disease

Weather based forewarning expert system for mango diseases

Powdery mildew, caused by fungus *Oidium mangifeae*, is an important and serious disease of mango. In cases of severe infection of the disease more than 50 per cent crop loss may occur (Misra *et al.*, 2010).The disease affects the inflorescence, stalk of the inflorescence resulting into heavy loss.

The disease spreads fast when the maximum temperature reaches around 35^{0}C, minimum temperature between 15 -17 °C, relative humidity between 50 – 60 per cent and wind speed is 2 -5 kmph. These conditions usually prevail in the northern parts of the country around middle of March.

Based on above findings, an expert system module was developed for weather based forewarning of powdery mildew disease, which takes into account three weather parameters *viz.*, maximum and minimum temperatures, relative humidity and wind speed to find out whether weather is conducive for development of powdery mildew or not? If weather parameters are favorable for the development of powdery mildew disease, then the system generates the forewarning and advises its management options for the same (**Figs**. 10, 11 and 5).

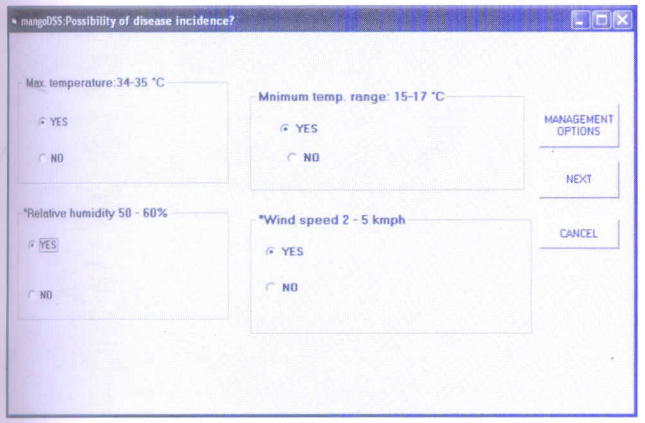

Fig.10 Expert system module for weather based forewarning of powdery mildew disease.

RESULTS AND DISCUSSION

In this paper, an object oriented approach of presenting rules in knowledgebase of expert system in form of Object- Attribute-Value have been utilized that allows developing knowledge base along with expert system directly without expert system shell software. The expert system for diagnosis of five major mango diseases *viz.*, Powdery mildew, Anthracnose, Bacterial canker, Phoma blight and Red rust have been developed. After diagnosis, the expert system advises the management options for diagnosed diseases (**Figs**. 5&9).

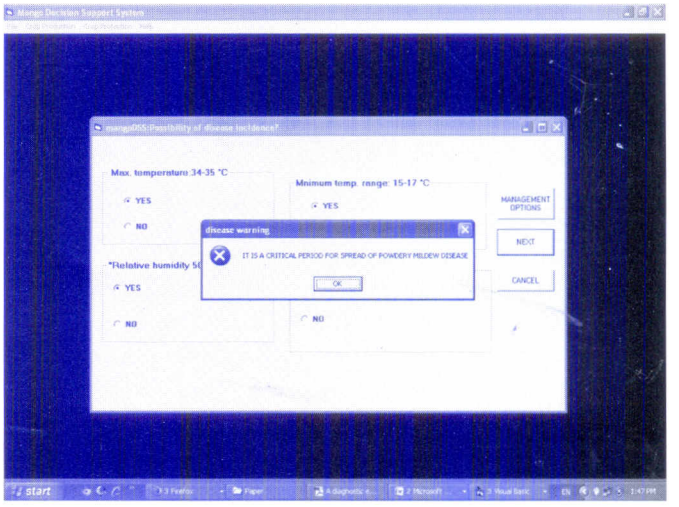

Fig. 11 A screen showing diagnosed powdery mildew disease.

A model based expert system for weather based forewarning of powdery mildew disease was developed that takes into account three weather parameters viz., maximum and minimum temperature, relative humidity and wind speed to find out whether weather is conducive for development of powdery mildew or not? If yes, then system advises its management/control options (**Figs**.10, 11&5).

The method of expert system development using object oriented approach of presenting rules in knowledgebase in form of Object- Attribute-Value allows development of expert system directly using a programming language as front-end and a database management system as back-end, without the use of costly expert system shell software, is presented. The expert system was developed to diagnose the Powdery mildew, Anthracnose, Bacterial canker, Phoma blight and Red rust diseases of mango. After diagnosis, it advises suitable management options of these diseases. This software is being expanded to cover all pests' diseases and disorders of mango. The system will serve as effective knowledge dissemination tool and will empower orchardist for effective decision making in mango production. The expert system was evaluated following the conventional expert system evaluation methodologies.The overall system evaluation research study included verification and validation processes (Harrison, 1991).The verification process ensured that the knowledge in the system is consistent, complete and correct according to required specification(Kolhe *et al.*, 2011). The knowledge base was

verified after compilation of all the rules and we made necessary alterations to ensure accuracy. Verification was done to ensure that there are no dead-end lines of reasoning that would result in unknown conclusions derived through the inference process. All the possible bugs in the system were located by the verification process. The functional performance was thoroughly checked. We ensured by running the software time and again by providing different combinations of all the possible inputs. The results given by the system have been validated with domain experts. It was found that the system performance was as expected.

REFERENCES

Gaines, B.R. 1987. An overview of knowledge acquisition and transfer. *International Journal of Man-Machine Studies* **26(4):** 453-472.

Harrison, S.R. 1991. Validation of agricultural expert system. *Agricultural System.* **35:** 265–285.

Harmon, P. and King, D. 1985. Expert Systems: Artificial Intelligence in Business. Wiley,

New York, NY, 283P.

Huirne, B.M.R. and Dijkhuizen, A.A. 1992. Application of decision support systems in farm management. *In: Preprints of European Workshop on Integrated System in Agricultural Informatics*, Bonn. pp. 61-71.

Kahney, H., 1989. Knowledge Engineering. The Open University, 238 P.

Kolhe, S.; Raj, K., Saini, S.; Harvinder and Gupta, G.K. 2011. A web-based intelligent disease-diagnosis system using a new fuzzy-logic based approach for drawing the inferences in crops. *Computers and Ele Agriculture*, **76:** 16-27.

Jun-chen, LAI; Bo, MING; Shao-kun, LI; Ke-ru, W zhi, XIE and Shi-ju, GAO 2010. An Image-Basec Expert System for Corn Diseases. *Agricultura China*, **9(8):** 1221-1229

Mahaman, B.D.; Harizanis, P.; Filis, I.; Antono Yialouris, C.P. and Sideridis, A.B. 2002. A expert system for honeybee pests, *Com Electronics in Agriculture*, **36:** pp. 17–31.

Man singh, G; Reichgelt, H. and Bryson, K.O. (20(An expert system for the management of diseases in the Jamaican coffee industry, *Ex with Applications*, **32:** 184-192.

Misra, A.K and Pandey, B.K. 2010. Integrate management practices in mango, CISH, Luck

Nitsch, U. 1991. Computers and the nature management. In: D. Kuiper and N.G. Rolling The Edited Proceedings of the European Se Knowledge Management and Information Te November 23-24, 1989, Wageningen The Ne Agricultural University, Dept. of Extensio Wageningen, pp. 99-106.

Ploetz, R.C. and Prakash, O. 1997. Foliar, floral and diseases. *In: The Mango: Botany, Production and* Litz, R.E., CABI Publishing, U.K., pp. 281-326.

Schoeman, M.H.; Manicom, B.Q. and Wingfield, M Epidemiology of powdery mildew on mango *Plant Disease* 79 (5): 524-528.

Yialouris, C.P. and Sideridis, A.B. 1996. An expert s tomato diseases. *Computers and Electronics in A* 14: 61–76.