Weather Based Plant Diseases Forecasting Using Fuzzy Logic

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***Abstract*-- Integrated Pest Management (IPM) is a comprehensive approach that integrates a variety of practices to minimize the loss of farm productions due to pests and pathogens with optimum use of pesticides. Early detection of pest and its control is one of the aspects of IPM. Weather based forecasting is well accepted method for this. Various meteorological data like- temperature, humidity, leaf wetness duration (LWD) plays the vital roles in the growth of microorganism responsible for disease. Effective forecasting of such diseases on the basis of climate data can help the farmers to take timely actions to restrain the diseases. This can also rationalize the use of pesticides, which are one of the causes behind land pollution. Weather based forecasting system can be considered as a part of the Agricultural Decision Support System (ADSS) which is Knowledge Based System (KBS). This paper proposes fuzzy logic based structure for the plant disease forecasting system. It has been demonstrated that the proposed method can be implemented with minimum weather data like- temperature and humidity**.

***Index Terms*-- Integrated Pest Management (IPM), Leaf Wetness Duration (LWD), Agricultural Decision Support System (ADSS), Fuzzy Logic**

I. INTRODUCTION

Indian's economy is agriculture based. Agriculture provides maximum employment in the country. Unfortunately, crops production heavily affected by the pests and diseases. Pest damages huge amount of the agricultural production [1]. After green revolution concept in India, uses of chemical pesticides and fertilizers were increased. Irrational use of pesticides creates a problem with the crop quality, land quality and the human health. Uncontrolled use of pesticides creates an economic loss to farmers as well as crop quality. The Integrated Pest Management (IPM) system intended to prevent pest problems before economic losses occur. The Integrated Pest Management system aims to utilize the least pesticides for the pest control [2]. Many IPM techniques are given in the literature such as optimum use of synthetic chemicals, use of natural pesticides, crop cultivars, crop rotations, biological control with natural enemies and decision support tools that informs the farmers when to apply pesticides [3]. Although many such improvements in IPM techniques crop production heavily reliant on the weather variability. Temperature, precipitation and solar radiation are the main drivers of the crop production [4]. Forecast based on temperature and precipitation are important to agriculture. Extreme climate conditions also negatively blow agriculture production, pest and diseases. Weather based forecast gives the early warning to the farmers. This helps to take the timely action against the diseases.

Agricultural Decision Support System (ADSS) presented in the paper, address weather based disease forecasting using fuzzy logic. The next section explains about weather based disease forecasting approach. Section III presents fuzzy logic based framework for disease forecasting.

II. WEATHER BASED DISEASE FORECASTING

Weather plays an important role in the development of a disease. The importance of weather in the formation and spread of the diseases is well explained with the disease triangle concept. [5]

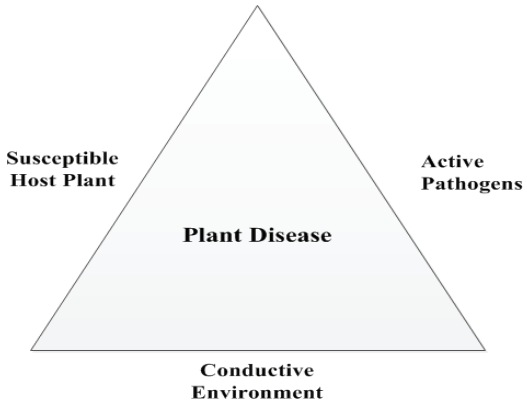

Fig.1 Disease triangle

Disease triangle concept graphically presented in fig.1. In order for disease to occur, three conditions must be happening simultaneously. First it is necessary to have a susceptible host plant. Each type of plant can be infected by only some pathogens. The plant must also be in a stage of development susceptible to infection by the disease agent. The second requirement is the presence of an active pathogen. If there is no pathogen present there can be no disease. Also, the pathogen must be in a phase of

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development favourable to infecting the host plant. The third condition is an environment suitable for the pathogen to cause disease of the plant. If early warning of weather changes which are favourable for disease is available then prevention of occurrence of the disease can be done. This is the foremost principle of weather based disease forecasting.

Weather forecasting is the application of science and technology to envisage the state of the atmosphere for a given location. A Weather detection, monitoring and early warning system can provide reliable and timely information to the farmers to deal with weather and climate variability and changes. Disease forecasts determine when to use pesticides [6]. Disease forecasting based on weather data evaluated in many studies. Weather based forecasting system use a highly sophisticated Automated weather station (AWS), Web based Internet system, Wireless communication Infrastructure, High Resolution camera. Use of various Meteorological data in Weather based forecasting system is given in many literatures [7], [8]. In many literatures it is found that temperature, relative humidity, precipitation rate, wind speed, solar radiation, leaf wetness duration (LWD) has a great impact on the occurrence of the plant diseases. LWD is a very useful parameter to weather based plant disease forecasting system but it is rarely measured in the weather station [9]. Various methods are available to estimate the LWD. These are based on measurement of the heat reflux rate, solar radiation , leaf canopy, temperature, humidity, water vapor pressure and wind speed [10]. In this paper, an estimation of LWD using only temperature and humidity using fuzzy logic is presented.

III. DISEASE FORECASTING USING FUZZY LOGIC

An expert system can be implemented using fuzzy logic, neural network, knowledge base system etc. In proposed paper, expert system for disease forecasting is developed using fuzzy logic. Model of fuzzy set theory and fuzzy logic is given by Zadeh [11]. Fuzzy logic is used in many applications like data mining, control applications, decision support system and other practical applications where the system is partially known. In many literature uses of fuzzy logic are demonstrated for the partially known systems. The agricultural system is a partial known and complex system. Fuzzy logic theory is very useful to develop a decision support system for an agricultural system [12]. Successful use of fuzzy logic in an agricultural system for different aspects of agriculture processes are presented in paper [13], [14], [15]. Fuzzy logic is a knowledge based system. The knowledge base is created by many ways. In the proposed work knowledge is generated by literatures surveys. Based on this knowledge, fuzzy logic is implemented. The proposed paper suggests the possible use of weather data: temperature and humidity for disease forecasting. Accurate data of temperature and humidity are always available with meteorological station. Disease formation happens in the specific range of temperature and humidity. In the literature, maximum and minimum values as favorable environment are defined as crisp values. Disease spreading also possible with the nearby crisp value of climate conditions. Linguistic description and implementation based on this is a more logical way. The fuzzy logic system reduced the mathematical computational aspect of various agriculture data like temperature, relative humidity, leaf wetness duration etc. Paper proposed the possible use of fuzzy logic in weather based plant diseases forecast system. Weather based forecasting is a technology that predicts the possibility of the diseases for the present state of the atmosphere in the given geographical area.

A leaf is an important part of the plant. The majorities of the pathogens are developed and grow on the surface of the leaf. Leaf wetness duration plays an important role in the growth of a disease. Leaf wetness duration is given as a degree of moisture associated with the vegetation [16]. LWD can measure by two approaches. The first and the foremost is use of various sensors. The second method is estimation of LWD by means of mathematical models. Measurement and accuracy of the LWD using sensor depends upon the number of sensors placed as well the location of the sensors [17]. A useful sensitivity analysis of leaf wetness in the potato plant canopy is given in [18]. Use of sensor to measure LWD has its own problem and it also involves cost. LWD estimation using mathematical model is given in [19]. Estimation of LWD using mathematical approach involves a measurement of various variables like soil moisture, wind speed, heat reflux rate etc. To accurately estimate all variables is difficult. Temperature and relative humidity parameter is primarily important for the estimation of Leaf wetness duration [20]. Estimation of LWD using fuzzy logic based on temperature and humidity measurement is discussed in presented paper. Proposed expert system is shown in Fig.2.

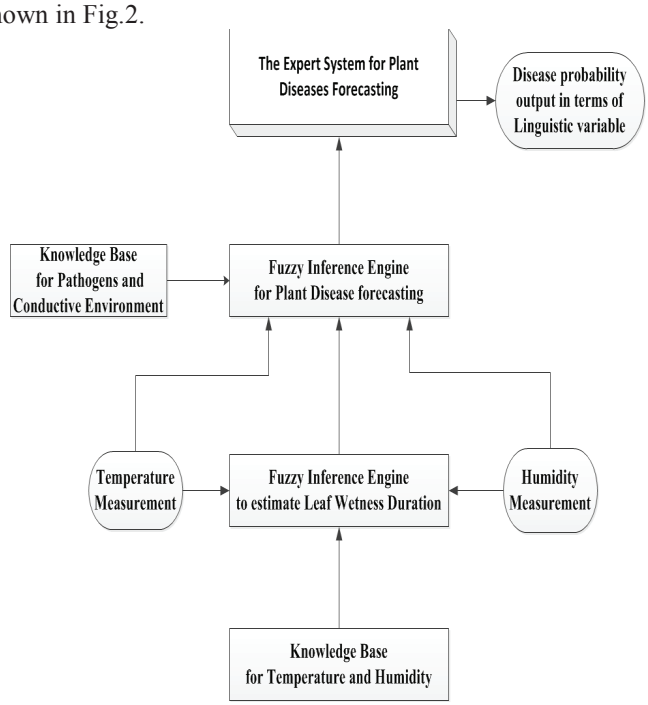


Fig. 2 Conceptual diagram of weather based plant diseases forecasting system

The fuzzy inference system is a knowledge based system. Some of the sample knowledge data used for the fuzzy inference system to forecast the disease shown in Table-1. This data represents for the corn crop. Various data shown in table-1 reveals the fact that a particular disease occurs when a specific active pathogen is present in the host plant along with favorable range of temperature, humidity and LWD.

Using knowledge of various high risk environmental data and knowledge of pathogen an expert system estimates the probability to occur a specific disease.

High Risk Environmental condition for Corn Crop

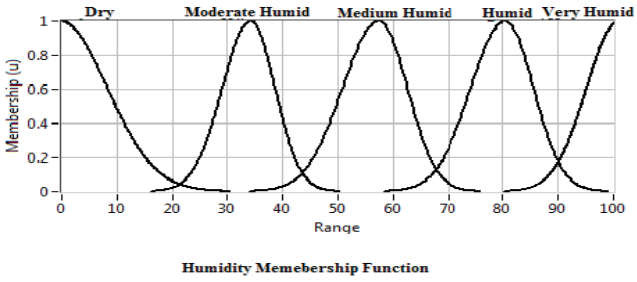
Disease/ Pathogen	Lower Probability Day Temp Range - °C	Higher Probability Day Temp Range - °C	Higher Probability Humidity %RH	Higher Probability Leaf Wetness Duration Hrs
Common Rust Pathogen: Fungus- Puccinia Sorghi	10 °C to 28.5°C	18.3°C to 23.8°C	98 to 100%	6 hours
Gray Leaf Spot Pathogen: Fungus- Cercospora Zeaemaydis	25°C to 32°C	27°C to 30°C	90%	12 hours

Table-1 Sample Data for disease forecasting knowledge base

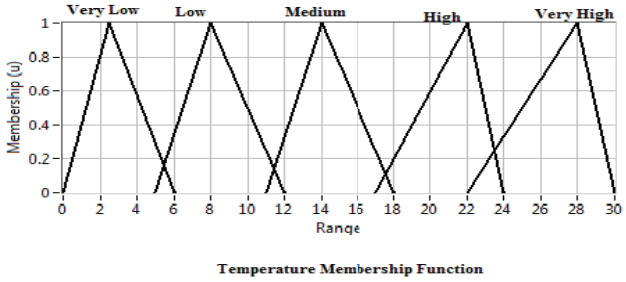
Precision of linguistic output is based on the significance of different membership functions. The common Rust disease is developed due to a fungus known as Puccinia Sorghi. This is one of the significant diseases of the corn crop. The input and output membership functions for the disease probability for different weather conditions are shown in Fig-3. In proposed work, the input and output membership functions are classified into five different classes of probability like Very high, high, medium, low and very low. Based on the membership function, rules are written in fuzzy system. Some of the sample rules are shown in Table-2. In proposed paper final output is given in terms of a linguistic variable that gives the early warning to the occurrence of diseases in the host plant. Early warning of disease optimizes the use of pesticide in the farm. Accuracy of forecasts is checked with the existing knowledge.

IV. DISCUSSION

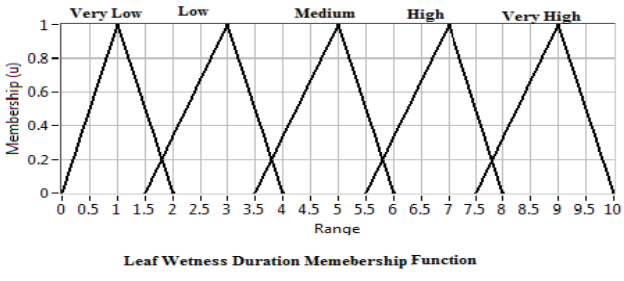
The proposed expert system utilizes the knowledge of favorable climate conditions for the different micro - organism responsible for the disease. These include range of temperature, range of humidity and LWD data. Using the available knowledge, the fuzzy inference system is developed. The FIS generates the output in terms of linguistic variables. In proposed paper, two diseases are considered to check the concepts. They are common rust and gray spot found in the corn. The knowledge of high risk environment is collected and used to frame FIS. The probability of occurring of the diseases in linguistic variables is an output of the system and works as a decision for the farmers. This linguistic output gives the early warning to the farmers about the probability to occur the disease. The farmers can take appropriate action on time. This will not only reduce the use of pesticide but timely use also enhances the protection of crop. Building up the expert system is a key. It is planned to create a suitable user interface such that the knowledge base can be updated very easily. In certain range of temperature, humidity and leaf wetness duration, there are probability of occurrence of more than one disease in the plant. Realization and implementation of combined disease forecasting in plant is future work.



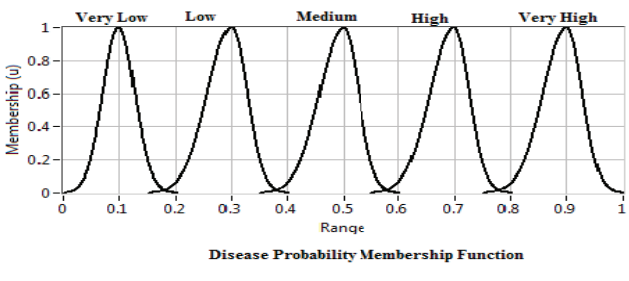
Humidity Memebership Function



Temperature Membership Function



Leaf Wetness Duration Memebership Function



Disease Probability Membership Function

Rule No	Rule
1.	If (Humidity is Dry) and (Temperature is very low) and (Leaf wetness duration is very low) then(Disease is very low)
2.	If (Humidity is Dry) and (Temperature is very low) and (Leaf wetness duration is low) then(Disease is very low)
3.	If (Humidity is Dry) and (Temperature is very low) and (Leaf wetness duration is medium) then(Disease is very low
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50.	If (Humidity is Moderate) and (Temperature is very high) and (Leaf wetness duration is very high) then (Disease is low).
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124.	If (Humidity is very High) and (Temperature is very high) and (Leaf wetness duration is very high) then (Disease is very high).
125.	If (Humidity is very High) and (Temperature is very high) and (Leaf wetness duration is very high) then (Disease is very high).

Table. 2 Fuzzy rules to estimate plant disease

V. CONCLUSION

Integrated pest management (IPM) is an approach to control diseases with the optimum use of pesticides. Weather based disease forecasting is one of the methods of IPM. Various meteorological data like temperature, relative humidity, leaf wetness duration and wind speed are used for the early detection for probability of disease in crops. Characterization of various meteorological data in linguistic variable is logical to describe favorable climate conditions for the diseases. Fuzzy logic gives the possibility to define linguistic variables. Presented expert system estimates the probability of occurrence of disease in the plant. This is an endeavor to give a thought of fuzzy logic structure for weather based plant disease forecasting. Implementation and Realization of expert system having an estimation of most of the plant disease are a future task.

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