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Design and Development of a Warning System for Early Season Control of Powdery Mildew Affecting Agricultural Crops.

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Abstract: *The crop management system using Wireless Sensor Network (WSN) is a kind of an autonomous solution to plant disease detection, an essential and critical operation which affects yield, cost and environmental protection against overusing of pesticide or fertilizer. Pesticides play an important role in pest control but their role is under criticism due to perceived excessive use and potentially harmful to the environment, humans and animals. Powdery Mildew, a fungal disease caused by species of fungi in the order Erysiphales, grows well in environments with high Humidity and moderate Temperature. A warning system is developed based on Low Power, Wireless Sensor Network for early season powdery mildew control based on (i) short term weather data, (ii) A model that simulates severity of disease infection and (iii) cell phone SMS warning system. Each sensor node wakes up from inactive mode by consuming less power and communicates to master or base station hourly basis in a day. This warning system is based on UC Davis Powdery Mildew Risk Index Model. It also warns disease severity through other environmental factors like humidity (50% to 85%) and wind speed (≥2 Kmph). Use of the warning system reduces disease severity and also helps farmer to decide fungicide spray program, which results in reduction in pesticide cost and increase in yield by controlling plant disease 'Powdery Mildew'. Therefore in this project we would like to propose system that will communicate and warn through SMS by analysing short term weather data.*

Keywords: *Powdery Mildew, Precision Agriculture, Relative Humidity, Temperature, Wind speed, Wireless SensorNetwork.*

I. Introduction

India being an agricultural country needs some innovation in the field of agriculture through modern technologies like modern Precision Agriculture (PA) using Wireless Sensor Networks (WSN). WSN in agriculture helps in distributed data collection, monitoring of environmental parameters for crop growth, yield, disease control etc. This paper presents the preliminary design and the development of WSN for environment monitoring for prevention and eradication of plant diseases before its growth and spreading. Powdery Mildew, a fungal disease caused by species of fungi in the order Erysiphales, grows well in environments with high Humidity and moderate Temperature and spreads through wind. Vegetables, Cereals, Pulses, Ornamentals, Spices, Fruit trees, Sugar crops, and several other plants of economic importance are affected resulting in significant yield reduction by reducing photo synthetic areas up to 30-90% approximately [1].

The main aim of this paper is to propose a state of art wireless sensor technology in agriculture to develop a warning system based on Low Power Wireless Sensor Network for early season powdery mildew control framed with (i) short term weather data, (ii) A model that simulates severity of disease infection and (iii) cell phone SMS warning system. Each sensor node wakes up from inactive mode by consuming less power and communicates to master or base station hourly basis in a day. This warning system is based on UC Davis Powdery Mildew Risk Index Model [2]. It also warns disease severity through other environmental factors i.e. humidity (50% to 85%) and wind speed (≥2 Kmph). Use of the warning system reduces disease severity and also helps farmer to decide fungicide spray program, which results in reduction in pesticide cost and increase in yield by controlling plant disease 'Powdery Mildew'. In this project, the sensor nodes have sensors to monitor Temperature, Relative Humidity & Wind speed, based on UC Davis model, these values are sent to the base station and in turn base station evaluate received data with risk index model and intimates the farmer about the possibility of occurrence, growth and spreading of disease via SMS using GSM modem. Obtaining the Risk Index value of Powdery Mildew disease in his mobile through SMS, the farmer selects the necessary pesticide and spray program for control of disease. Hereby the amount and frequency of pesticide sprinkling can be reduced. In order to overcome the lack of appropriate information and technical support and to increase the yield, a development of Powdery Mildew disease monitoring and warning system using Low Power WSN is proposed to provide a helping hand to farmers through real-time monitoring, achieving precision agriculture and thus increasing the yield and reducing expenses.

II. Literature Review

P. Sinha et.al. in his paper entitled "Statistical Modelling and Forecasting of Powdery Mildews Affecting Agricultural Crops: An Overview" observed that weather factors, mainly temperature and relative humidity above threshold limits, are key factors for occurrence of disease powdery mildew [1]. Herman sahota and et.al. in his paper entitled "An Energy-efficient Wireless Sensor Network for Precision Agriculture" stated that, the use of wireless sensor networks is essential in implementation of information and control technologies in application areas such as precision agriculture [8]. N. Sakthipriya in paper entitled "An Effective Method for Crop Monitoring Using Wireless Sensor Network" a development of rice cropping monitoring using WSN is proposed to provide a helping hand to farmers in real-time monitoring, achieving precision agriculture and thus increasing the rice production [2]. In an article "Developing a New Wireless Sensor Network Platform and Its Application in Precision Agriculture", Raúl Aquino-Santos proposed a new platform for wireless sensor networks including its embedded operating system and its routing algorithm was evaluated in terms of route discovery time, packet delivery ratio, End-to-End delay, Throughput, routing load and overhead [9].

III. Requirements of WSN Based Monitoring:

The requirements in the aspect of WSN based environmental parameter monitoring system functions can be mainly summarized as the following points:

3.1 Hardware

MSP430F22x2 series microcontroller and GSM SIM-900 at Base/Master node with IEEE 802.15.4 based CC2500-RTR1 RF Transceiver operating in the 2.4GHz band. Each sensor node consists of Temperature Sensor PT100, Humidity Sensor HTF3000LF-710311 and Wind Speed Sensor – Anemometer with CC2500-RTR1 RF Transceiver.

3.2 Software

- Altium 14.0 is used to draw Schematic & Layout for sensor node, master node, RF transceiver, GSM module and power supply.
- IAR Compiler and MultiSim 10 is used to compile, simulate and run programs designed for intended system.
- TI-MSP430 USB Stick is used for Debugging,
- GUI Development using MATLAB 13.

IV. System Architecture

The requirements that adopting a WSN are expected to satisfy effective agricultural monitoring which concern both system level issues and final user needs i.e. communication reliability, robustness, user friendliness, versatile and powerful graphical user interfaces. Main features of the developed system are

- CC2500 RF Transceiver based WSN with very low energy consumption for long battery life.
- Three nodes to monitor environmental data and mean is taken into consideration for accuracy.
- Measured data stored in a database and analyzed with Risk Index Model

IEEE 802.15.4 RF Transceiver Operates at THREE unlicensed band, as below

1. 868 MHz – Single channel, 20 kbps, -92dBm.
2. 915 MHz – Ten channel, 40 kbps, -92dBm.
3. 2.4 GHz – Sixteen channel, 250 kbps, -85 dBm, range up to 220 mater.

Even if requirements are strongly application dependent, one of the most important issues in the design of WSNs, especially in such scenarios where power supply availability is limited, is *energy efficiency*. High energy efficiency means long network lifetime and limited network deployment and maintenance costs. The CC2500 is a low-cost 2.4 GHz transceiver designed for very low-power wireless applications. The circuit is intended for the 2400-2483.5 MHz ISM (Industrial, Scientific and Medical) and SRD (Short Range Device) frequency band with data rate up to 500 kBaud.

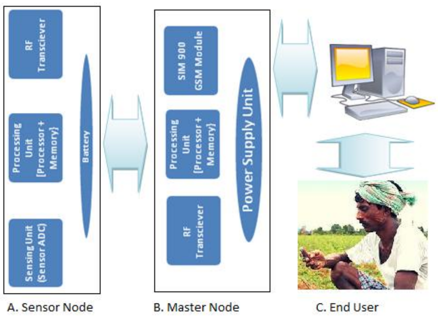

Fig. 01 System Architecture of WSN for Warning System for Early Season Control of Powdery Mildew.

The system, shown in Fig. 01, comprises an overall self-organizing WSN with sensing capabilities, a Node. All the deployed nodes will collect the environmental parameters and report to the central co-ordinator / master node. Master node interfaced with personal computer analyzes with UC Davis Powdery Mildew Risk Index Module and will excite the SMS via GSM modem about possibility of occurrence and/or growth of fungus in that particular region, intimating him about susceptible environmental conditions and to necessary action to control growth of fungus in that region.

UC Davis Powdery Mildew Risk Index Model

Risk index ranges from 0 -100 for Temperature

- Requires 3 consecutive days with at least 6 hours between 21-30°C to trigger the index.
- Index increases 20 points each day with at least 6 hours between 21-30°C.
- Index decreases 10 points each day with less than 6 hours between 21-30°C.
- Index decreases 10 points on any day with a minimum temperature above 35°C.
- An index of 60-100 indicates the pathogen is reproducing every 5 days.
- An index of 0-30 indicates the pathogen is functioning minimally and reproductive rate is every 15 days or not at all.

The effects of humidity on powdery mildew development :- Disease on foliage was markedly affected by humidity levels in the test range of 39 to 98% relative humidity (RH). Incidence and severity increased with increasing humidity to an optimum near 85% RH, and then appeared to plateau or decrease marginally at higher values.

Dispersal of conidia of powdery mildew is increases with wind speed ≥ 2 Km/h.

For the realization of the proposed system, Graphical User Interface (GUI) is designed using programming environment MatLab. It is a graphical programming language, having a powerful library of functions.

V. Result & Discussion

Environmental data is collected from THREE sensor node placed at different places with temperature sensor, relative humidity and wind speed with an interval of ONE hour for all three sensors. Average of three readings collected from nodes, is considered for analysis with UC Davis Risk Index Model and other standards defined as below mentioned for severity of disease Powdery Mildew.

Fig. 02 shows readings for 72 hours temperature. Here in the three consecutive days temperature remains in the range of 21 to 26°C, which triggers the risk index.

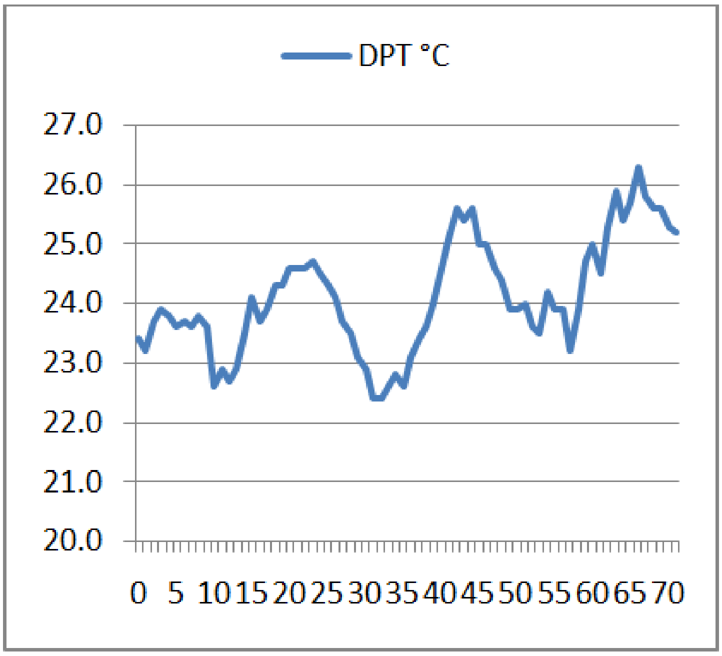

Fig. 02 Temperature in °C for 72 Hours.

Fig. 03 shows readings for 72 hours relative humidity. Here in the three consecutive days relative humidity vary from 60 to 99%, which triggers the severity of risk index with increase in relative humidity up to 85% and decrease marginally with increase in further humidity.

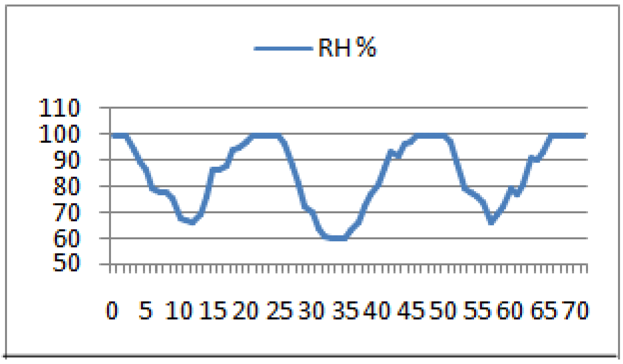

Fig. 03 Relative Humidity in % for 72 Hours

Fig. 04 shows readings of wind speed for 72 hours. Here in the three consecutive days wind speed more than 2Kmph leads to dispersal of conidia of powdery mildew.

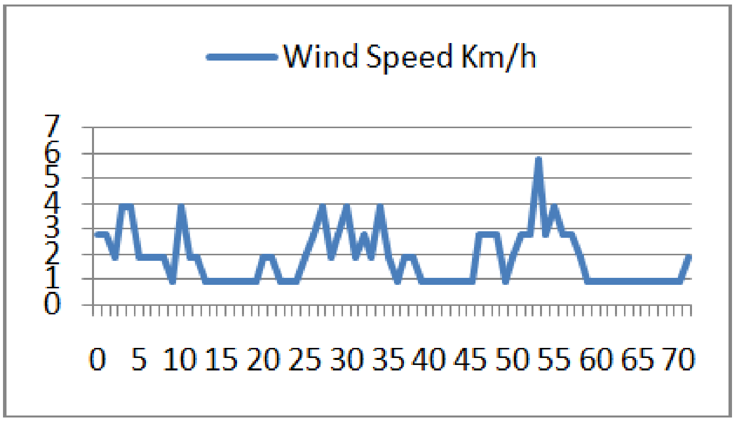

Fig. 04 Wind Speed in Kmph for 72 Hours

When Risk Index reaches above 60% along with relative humidity and wind speed, warning message is sent from the base station and in turn base station intimates the farmer about the severity of disease via SMS using GSM modem. Obtaining the Risk Index value of Powdery Mildew disease in his mobile through SMS, the farmer selects the necessary pesticide and spray program for control of disease.

VI. Conclusion

A developed warning system is based on Low Power Wireless Sensor Network, where it consumes low amount of power during communication to base station and very negligible during idle mode which helps to sustain long life of each node at remote place. A warning message is sent to farmer when any of the environmental parameter, Temperature (21 to 30°C) humidity (50% to 85%) and wind speed (≥2 Kmph) is in disease severity state. Real time and remote monitoring helps the farmer to take necessary action of about spraying pesticide only when required. This mechanism proves beneficial as it works on the principle of "Prevention is better than Cure". Use of the warning system reduced disease severity and also helps farmer to decide fungicide spray program, which results in reduction in pesticide cost and increase in yield by controlling plant disease 'Powdery Mildew'.

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