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Research Article

MONITOR AND CONTROL OF ENVIRONMENT IN NATURALLY VENTILATED POLYHOUSE BY USING SENSOR NETWORK

PARDHE D.D.*[1], BHAKAR S.R.[2], KOTHARI M.K.[3], KUMAR R.[4], JOSHI S.[5] AND LAKHAWAT S.S.[6]
[1]Department of Soil and Water Engineering, College of Technology and Engineering, Maharana Pratap University of Agriculture and Technology, Udaipur, 313001, India
[2]Professor, Department of Soil and Water Engineering, College of Technology and Engineering, Maharana Pratap University of Agriculture and Technology, Udaipur, 313001, Rajasthan, India
[3]Professor and Head, Department of Soil and Water Engineering, College of Technology and Engineering, Maharana Pratap University of Agriculture and Technology, Udaipur, 313001, Rajasthan, India
[4]Professor and Head, Department of Electrical Engineering, Malviya National Institute of Technology, Jaipur, 302017, Rajasthan, India
[5]Professor and Head, Department of Electronics and Telecommunication Engineering, College of Technology and Engineering, Maharana Pratap University of Agriculture and Technology, Udaipur, 313001, Rajasthan, India
[6]Professor and Head, Department of Horticulture, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur, 313001, India
*Corresponding Author: Email - pardhedd@gmail.com

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Abstract: Polyhouse is a framed or inflated structure covered with transparent or translucent polythene papers, large enough to grow crops under partial or fully controlled environmental conditions to get maximum productivity and quality produce. The experiment was conducted at Plasticulture Farm, College of Technology and Engineering, MPUAT, Udaipur, Rajasthan during May, 2018 to April, 2019 to monitor and control the polyhouse environment favourable to get maximum productivity of tomato crop. The proposed automation unit is an embedded system which constantly monitors climatic parameters by temperature and humidity sensors and checks if the sensor values of these climatic parameters are within the range of threshold value or more. Every time a SMS notification is sent to the farmer's mobile about temperature increases than predefined value so that he can take the action immediately. In this experiment, several measurement points were required to trace down the local climate parameters in different parts of the greenhouse to make the greenhouse automation system work properly. Accordingly, four pairs of temperature and humidity sensors were placed in the four corners of the polyhouse. The data of temperature and humidity was collected by manually for the verification of sensor data.

Keywords: *Arduino Mega 2560, Climatic Parameters, Microcontroller and Sensors*

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Introduction

Appropriate environmental conditions are necessary for optimum plant growth, improved crop yields and efficient use of water and other resources. Greenhouse plays an important part of the agriculture and horticulture sectors in our country as they can be used to grow plants under controlled climatic conditions for optimum produce. There is need to monitor and control various environmental parameters like temperature, humidity, light, water content, *etc.,* which gives relevant information pertaining to the individual effects of the various factors towards obtaining maximum crop production. Unlike open farming where natures control takes the upper hand, green house prevents a closed environment that can be strictly controlled by humans in order to provide optimal conditions for the growth of plants [1]. A sensor is a device that detects and responds to some type of input from the physical environment. The specific input could be light, heat, motion, moisture, or any one of a great number of other environmental phenomena. The most imperative factors for the quality and yield of plant growth are temperature, humidity, light and the level of the carbon dioxide. Constant noticing these variables of these gives' information to the person to better understand, how each aspect affects growth and how to administer maximal crop productiveness [2-7].

Materials and Method

The proposed system is an embedded system which will closely monitor and control the microclimatic parameters of a greenhouse on a regular basis round the clock for cultivation of tomato crop which could maximize their production over the whole crop growth season and to eliminate the difficulties involved in the system by reducing human intervention to the best possible extent. The system comprises of sensors, microcontroller, and actuators. When the temperature in polyhouse crosses a safety threshold value which must be maintained to protect the crops, the sensors sense the change and the microcontroller reads this from the data at its input ports after being converted to a digital form. The microcontroller then a SMS notification is sent to the farmer's mobile through GSM module about temperature increases than predefined value so that he can take the action immediately or can take needed actions through relay module for starting the foggers until the strayed - out climatic parameters has been brought back to its predetermined values. As the system also employs an LCD display for continuously alerting the user about the condition inside the greenhouse, the entire set-up becomes user friendly. Relay switches the water pump, foggers based on the instruction given by the microcontroller. This system is easy to install and portable [8-14].

Arduino Mega 2560

Arduino Mega board is a microcontroller board based on Atmega2560. It can be programmed with the Arduino software. The Atmega2560 on the Arduino Mega comes preburned with a boot loader that allows us to upload new code to it without the use of an external hardware programmer.

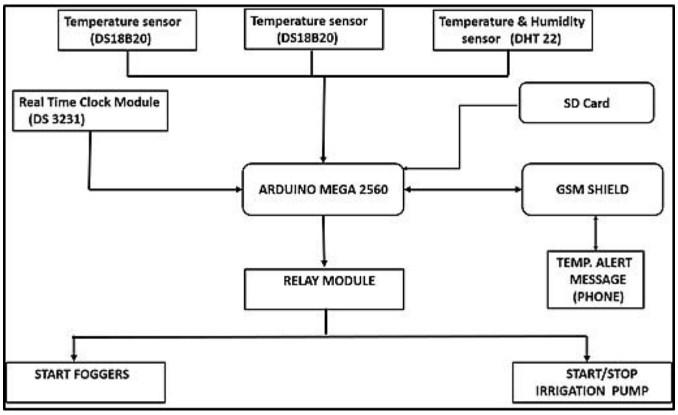

Fig-1 Set up for monitoring and controlling polyhouse climate

There are 54 digital input and output pins; 14 of which can be used as pulse-width (PWM) outputs. It has 16 Analog inputs, 4 UARTs (hardware serial ports), a 16 MHz quartz crystal or oscillator. Arduino Mega board has USB (universal serial bus) connection to connect to a computer by cable, a power jack, an ICSP (In Circuit Serial Programming) header and a reset button [15]. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with AC-to-DC adapter or battery to get started. The Mega is compatible with most shields designed for the arduinoDuemilanove or Diecimila.

Temperature and humidity sensors

Sensors used	Variables Monitored	Its Importance
DS18B20	Temperature	Affects all plants metabolic function
DHT 22	Humidity	Affects transpiration rate and the plants thermal control mechanism

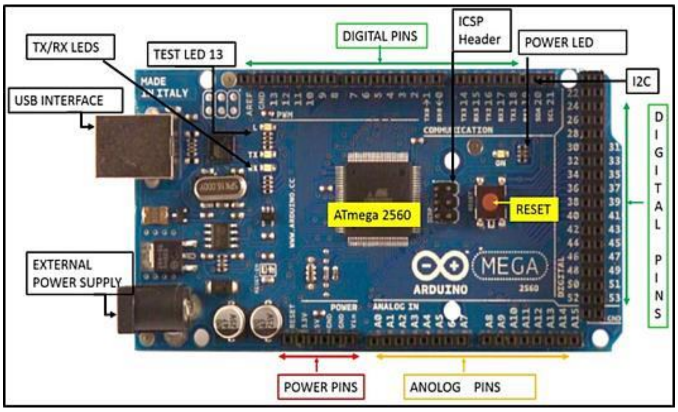

Fig-2 Arduino Mega 2560 Microcontroller

3. Real Time Clock (RTC): The device incorporates a battery input, and maintains accurate timekeeping when main power to the device is interrupted.
4. Micro SD Card Shield: The micro- SD Card Module is a simple solution for transferring data to and from a standard SD card.
5. Liquid Crystal Display (LCD): Liquid Crystal Displays are very popular and broadly used in electronics projects as they are good for displaying information like sensors data from the project, and, they are very cheap.
6. GSM Module: SIM900 is designed with a very powerful single-chip processor integrating AMR926EJ-S core. It is SMT type suit for customer application. The data transfer uses an embedded powerful TCP/IP protocol stack.
7. Relay module: The relay module is an electrically operated switch that allows us to turn on or off a circuit using voltage and/or current much higher than a microcontroller could handle.

Results and Discussion

All the connections and wiring were done as shown in the [Fig-1], the codes were developed with the help of an original source [16]. It is given in a format that can work by simply copying and pasting in IDE. After writing, the codes given above should be verified by IDE and when the verification complete, the program was ready to upload in Arduino. After safe system booting, the code written in IDE tells the Arduino to function so that the measurement obtained from sensors can be read and stored in the SD card and display temperature and humidity readings on LCD continuously. While the programme was running, the LCD display shows the reading continuously.

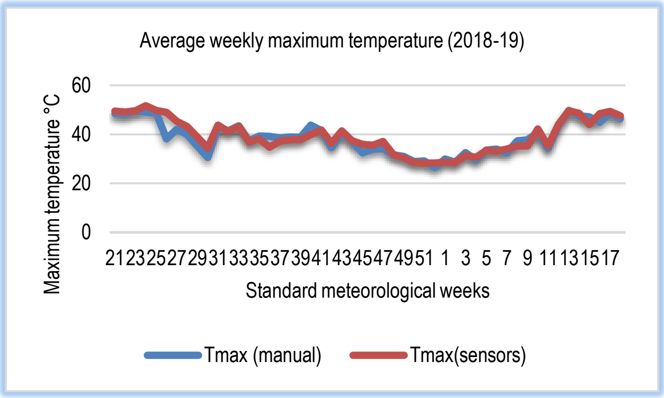

Fig-3 Comparison of weekly maximum temperature recorded by manually to sensor network

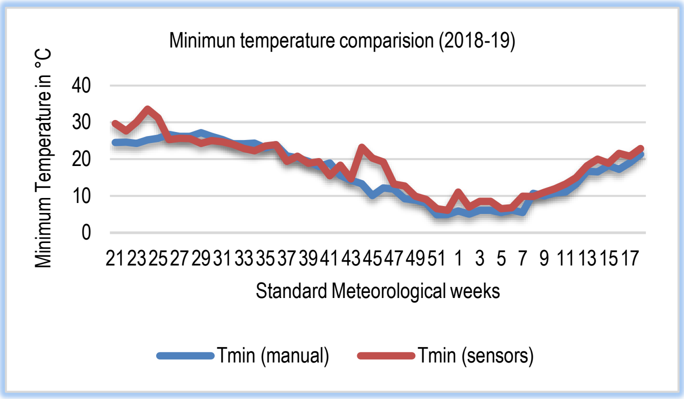

Fig-4 Comparison of weekly minimum temperature recorded by manually to sensor network

In the [Fig-3] shows the comparison of weekly maximum temperature recorded manually and received by wired sensor network for the crop period (2018-19) and [Fig-4] shows the comparison of weekly minimum temperature recorded manually and received by wired sensor network for the years 2018-19. The observed values of weekly mean maximum temperatures showed good agreement with the values recorded by the sensor network deployed in the NVPH.
The weekly average values of maximum relative humidity for the year 2018-19 recorded by manually and by sensor network depicted in the [Fig-5] and weekly average values of minimum relative humidity for the year 2018-19 recorded by manually and by sensor network depicted in the [Fig-6].

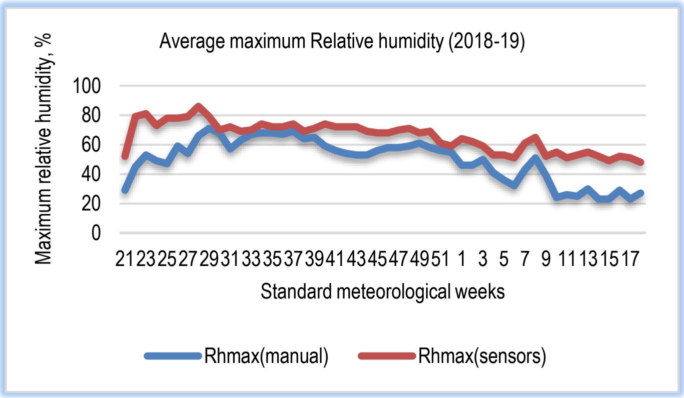

Fig-5 Comparison of weekly maximum relative humidity recorded by manually to sensor network

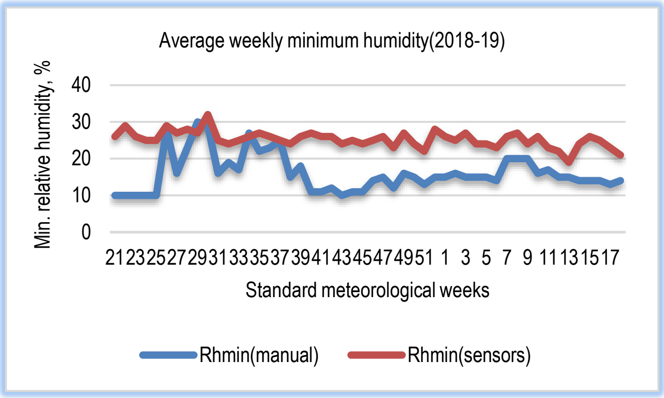

Fig-6 Comparison of weekly minimum relative humidity recorded by manually to sensor network

The values of weekly mean maximum humidity recorded by manually were lowest as that of received by the sensor network deployed in the NVPH. Looking to the comparison between the values of maximum relative humidity and minimum relative humidity observed manually and by sensor network shown in [Fig-5] and [Fig-6], these values showed poor agreement with the observed values. The observed values are lower than that of sensor values, due to the reason that the manual values are taken only two times in a day while sensor network received the values for continuous 24 hours of the day *i.e.*, day and night, so at the night time humidity will be high as compare to daytime. However, values of minimum humidity show the good agreement with 5 per cent error only. The above presented results were in good confirmation with the findings of Shin *et al* (1998) [17]. Hence, developed low-cost monitoring and control greenhouse system based on an Arduino technology is working successfully.

Conclusion

A systematic approach in designing the microcontroller based embedded system for monitoring and control of the climatic parameters required for plant growth *i.e.*, maximum temperature, minimum temperature, maximum humidity, and minimum humidity, has been followed. Currently farmers don't have any system which will show real-time levels of these parameters. Even farmer do not know when humidity is increased or temperature increased in his green house, because of it crop production gets affected. The proposed system is going to monitor these changes periodically and take an action automatically or pretend the required action to the farmer. There is wide scope to improve the performance of the system by increasing operating speed, capacity of memory and instruction cycle period of the microcontroller by using AVRs and PICs controllers. The number of sensors can be increased by using advanced version of microcontrollers. Later on, farmer can operate the devices from remote location by using its smart phone.

Application of research: This network can help to monitor and control all the environmental parameter of precision agriculture. The system supported with diagnostic sub system to make greenhouse manger to monitor system status especially if he sits far from system deployment.

Research Category: Agriculture and Technology

Abbreviations: DHT-Digital Humidity and Temperature,
IDE-Integrated Development Environment, LCD-Liquid Crystal Display

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****Research Guide or Chairperson of research: Dr S.R. Bhakar**
University: Maharana Pratap University of Agriculture and Technology, Udaipur, 313001, Rajasthan, India
Research project name or number: PhD Thesis

Author Contributions: All authors equally contributed

Author statement: All authors read, reviewed, agreed and approved the final manuscript. Note-All authors agreed that- Written informed consent was obtained from all participants prior to publish / enrolment

Study area / Sample Collection: Plasticuture Farm, College of Technology and Engineering, Udaipur, 313001, Rajasthan, India

Cultivar / Variety / Breed name: Tomato crop *cv* Dev

Conflict of Interest: None declared

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.
Ethical Committee Approval Number: Nil

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