SMART AGRO-INCUBATOR

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Abstract - *Agriculture is the backbone of the global economy and largest livelihood provider in India. About 95% of plants are grown in open fields and conventional methods are not sufficient for the ever-growing world population. Traditional methods incorporated greenhouses into the farming system. Operating greenhouses require tremendous amounts of manpower. Automating these greenhouses makes the process more efficient and reliable. Our project Smart Agro-Incubator aims to develop a system that focuses on the growth of plants in its initial stage thereby producing healthy and more productive plants. Smart Agro-Incubator has the facility to provide different growing conditions for each of the plants. The plants are kept at optimum temperature, humidity, light, moisture, and pH value for optimum production. It ensures that there is no 'off-season' and 'regional difference' in growing crops. Implementing conventional methods of irrigation inside the incubator is a tedious task and also to make irrigation more productive and effective we have decided to introduce the concept of Aeroponics.*

Index Terms: Greenhouse, Agro-Incubator, Aeroponics

1. INTRODUCTION

The basic principle of Aeroponics is to grow plants suspended in a closed or semi closed environment by spraying on to the plant's dangling roots and lower stem with an atomized or sprayed, nutrient-rich water solution. High-pressure aeroponics is defined as delivering nutrients to the roots via 20–50 micrometer mist heads using a high-pressure atomizer. The roots of the plant are separated by the plant support structure. Often, closed-cell foam is compressed around the lower stem and inserted into an opening in the aeroponic chamber, which decreases labour and expense. Ideally, the environment is kept free from pests and disease so that the plants may grow healthier and more quickly than plants grown in a medium. However, since most aeroponic environments are not perfectly closed off to the outside, pests and disease may still cause a threat. Controlled environments advance plant development, health, growth, flowering and fruiting for any given plant species. Since this is an incubator setup it separates the growing environment from the external factors that affect the growth. Regular updates can be viewed from an android app and controllers can be directly activated over the internet. This is done with the aid of an android app developed through Android Studio and an online database. The result of this project is an easier and more efficient means of managing plant growth and enhancing agriculture and so anyone can access high yield of farming.

2. LITERATURE SURVEY

In the present scenario, availability of power and water are insufficient to satisfy the farmer's requirements. Traditionally, implemented techniques of irrigation are proving to be less futile. With the merger of automation and the methods of irrigation used earlier, the scope to mitigate issues concerning water and power crisis is huge [1] In order to deal with this issue of global food shortage[3] households must need to grow a reasonable deal of vegetables and other crops using artificial greenhouses. An artificially controlled greenhouse yields more crops per square meter compared to open field cultivation since the microclimatic parameters that determine crop yield are continuously examined and controlled to ensure that an optimum environment is created. This automated system works using sensors and actuators, which are controlled by a microcontroller and monitor and manage every environmental parameter required for the good growth of plants.

Smart precision-based[5] agriculture makes use of wireless sensor networks to monitor the agricultural environment. Zigbee and raspberry pi-based agriculture monitoring systems serve as a reliable and efficient method for monitoring agricultural parameters. Wireless monitoring of the field not only allows the user to reduce the human power, but it also allows the user to see accurate changes in it. It focuses on developing devices and tools to manage, display and alert the users using the advantages of a wireless sensor network system. A smart system based on precision agriculture would pave the way to a new revolution in agriculture. The user can monitor the agriculture environment from a remote location, thus providing a greenhouse condition for the. plants. India being an agro based economy; precision agriculture can bring about an improvement in the primitive methods, thus developing the country stature hugely

The proposed system in[2] automates greenhouse farming by regulating climatic conditions in the greenhouse according to the plant specified from the database. The plants are kept at optimum temperature, humidity, light and soil moisture levels with little or no input from the user. Regular updates can be viewed from an android application and controllers can be directly activated over the internet with the click of a button. This is done with the aid of an android application and online databases. The result of this project is an easier and more efficient means of managing plant growth and a means of enhancing food production. With the aid of the project, anyone can access high yield of farming and therefore be self-sustainable in the aspect of food production

In [7]Internet of Things (IoT) enables various applications crop growth monitoring and selection, irrigation decision support, etc. A Raspberry Pi based automatic irrigation IOT system is proposed to modernize and improve productivity of the crop. Main aim of this work is to crop development at low quantity water consumption. In order to focus on water available to the plants at the required time, for that purpose most of the farmers waste a lot of time in the fields. An efficient management of water should be developed and the system circuit complexity to be reduced.

3. OBJECTIVES OF PROPOSED SYSTEM

This project aims to create a system that focus on the growth of plants in its initial stage thereby producing healthy and more productive plants. This will be achieved through the following objectives:

- To focus on the growth of plants in its initial stage
- This has the facility to provide different growing conditions for each of the plants inside the incubator.
- No off-season and regional difference.
- Automating the basic control elements in the incubator.
- Real time updates though an android app and controllers can be activated through the internet.

4. HARDWARE DESCRIPTION

4.1 Raspberry pi4

Raspberry Pi 4 Model B provides ground-breaking upgrades related to the pre-generation Raspberry Pi 3 ModelB+ in processing speed, graphics, memory, and networking while maintaining backward compatibility and consistent power consumption. Pi 4 B is upgraded to Latest High-Performance Quad-Core 64-bit Broadcom 2711, a clocked 1.5GHz Cortex A72 processor which is configured to use 20 percent less power than its old version. Hardware update on Pi4 has been built for better output not only for loading time with all recent models of 1GB/2 GB and 4 GB LPDDR4 SDRAM, but also for 2.4GHz and 5GHz dual-band networking, 802.11 b / g / n / ac wireless LAN and PoE compatibility with a different PoE HAT. In addition to the USB 3.0, boost transmission speed by 10x over USB 2.0 to provide you with a substantially faster real Giga LAN and PoE functionality. With the updated Bluetooth 5.0 technologies, making the IoT system easier with 2 x Speed, 4x Range and 8 x Data transmission rates, providing long-distance communication. Raspberry Pi 4 B has Type-C USB port from which Pi can run up to 3A, and thus Pi 4 can offer more power to onboard chips and interfaced peripherals.

4.2 Temperature-Humidity Sensor Module (DHT11)

DHT11 consists of a moisture sensing capacitive element and a temperature sensing thermistor. The capacitive sensing component has two electrodes with a moisture-holding substrate as dielectric between them. Any change in the moisture content will cause change in resistance between the electrodes. The IC inside this sensor will transform these changed resistance values into digital form and is given to the raspberry pi unit. For measuring temperature this sensor uses a negative temperature coefficient (NTC) sensor or thermistor. A thermistor is a variable resistor that changes its resistance with changes in temperature. NTC thermistor allows the resistivity value to decrease with rise in temperature. The temperature range of DHT11 is from 0 to 50-degree Celsius with a 2-degree accuracy. Humidity range of this sensor is from 20 to 80% with 5% accuracy. DHT11 is small in size with operating voltage from 3.5 to 5.5 volts. The maximum measurable current is 2.5mA.

4.3 Light Dependent Resistor

It is a photoconductor whose resistance value varies as light falls down on it. It is essentially a photocell which operates on the photoconductivity theory. Photoconductivity is an optical and electrical phenomenon in which due to the absorption of light the substance is electrically conductive. When the incident light intensity becomes greater than the bandgap limit then electrons are accelerated from the valence band to the conduction. This passive element is simply a resistor, where the magnitude of resistance in darkness is megaohms, and a few hundred ohms in bright light. In order to provide light sensitive properties, they are made-up of special semiconductor materials such as cadmium sulphide (CdS), lead sulphide (PbS) and indium antimonide (InSb) which detects light in infrared range.

4.4 Actuators

1. Grow Light: They are used for helping photosynthesis in the incubator in the absence of sunlight. It consists of 28 pieces of 5730SMD LED chips: 15Red + 7Blue + 2 daylight white + 2 warm light + 1IR + 1UV, providing the entire spectrum of light needed by the plant for growth. It has highly efficient heat dissipation. The aluminium body construction and ribbed design keeps the unit cool and highly efficient in luminosity; light operates easily for 24+ hours without any overheating. They will produce an

equivalent light output of 18W with power consumption of about 10W.Input Voltage is 220V.

2. Heating/Cooling fan: Heating fan will pull out hot air from Exhaust fan and incubator when temperature rises. The hot air is vented outdoors using the small fast-moving blades of the fan and thereby reducing the temperature. Cooling fans will draw cool air from outside into the incubator and cools down the incubator.

3. Ultrasonic Mist Maker Atomizer: Here we are using a new method of irritation called Aeroponics (Fogponics). The ultrasonic mist maker emits water or nutrient solution needed for the plant's growth in the form of fertilizer infused mist. It is basically a piezoelectric transducer producing high energy vibrations which cause the water to turn into fog. There is a built-in sensor present which detects the presence of water and it causes the transducer plates to vibrate. These vibrations will cause the water to transform into droplets that vaporize into particles of fog.

5. SOFTWARE ARCHITECTURE

5.1 Data Storage

Data for this project is stored on a third-party site called Thing speak. It allows you to send sensor data to the cloud. The data can be viewed in the form of graphs showing changes in humidity, light levels, temperature and water levels. A get request is sent from the application every 15 seconds and the data currently on Thingspeak is updated. Thingspeak is free for small noncommercial projects.

5.2 Android Application

The android application is developed to monitor the real time updates of the environmental variables. Application can be also used to control the parameters. It communicates with the raspberry pi with the help of built in Bluetooth module

The android application is made using Blynk which is an IOT platform. Here the android apps can have control over raspberry pi, Arduino etc through the internet. The most important part of the android application is the app components. The components of the app are activities, services, broadcast receivers and content providers, each of which has its own purpose and lifecycle.

Activity is the point of entry which is used to communicate with the users. It consists of a user interface with a single screen. Services run in the background to perform long running operations. It does not provide a user interface. An activity can start the service and run it in the background. Broadcast receivers allow the network to transmit the events to the app, allowing the app to respond to system wide broadcast announcements. The program will transmit the broadcasts to the app that doesn't even run. Content providers have a shared set of app data that can be stored in a file system that the app can access. Other apps can query or modify the data through this app component if permitted by the content provider.

6. PROPOSED SYSTEM

The proposed system contains 4 sections:

1. Input Unit
2. Controller Unit
3. Data Storage
4. Android Application

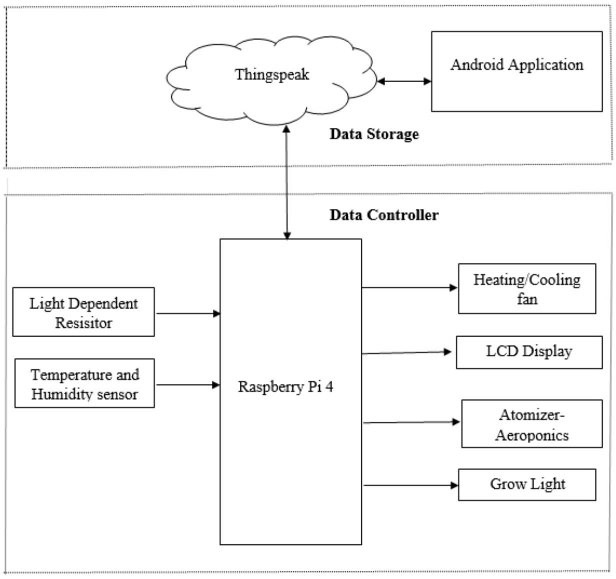

Fig.6.1 Block diagram of proposed system

The input unit contains a power supply unit and different sensors such as light sensor (LDR) and Temperature and Humidity sensor module (DHT11). These sensors will acquire different parameters such as light intensity levels, temperature and humidity levels inside the incubator and are given to the microcontroller unit. Majority of the components make use of a constant 12V power supply. This is obtained through the rectification of stepped down AC voltage from mains. Part of the control mechanism the grow light runs on 220V AC. The sensors require 5 and 3.3V which is supplied by Raspberry Pi 4.

The controller unit contains Raspberry Pi 4 and different actuators. The different parameters from the sensor unit are given to the Raspberry Pi 4 and it compares these values with the threshold value stored in the database. If any of the parameters varies from the threshold level corresponding actuators are turned on or off automatically by the controller. The grow light will provide artificial sunlight for plants and the LDR will sense the light intensity level based on the threshold level set inside the database. When the LDR senses light intensity greater than the threshold value then it automatically turns off the grow light. Also, when intensity is below the threshold value then Pi 4 B will automatically turn on the grow light. LDR output is analog in nature and using ADC digital data is given to Pi 4 B. The temperature sensor (DHT11) inside the incubator senses the temperature changes, when the temperature is more than the threshold value then the exhaust fan will turn on and bring the desired temperature. Different plants have different environmental conditions for growth, that is some needs very low temperature then the cooling fan comes in action. It helps to keep the lower temperature inside the incubator.

The major challenge of growing different plants collected from different areas is the difference in the soil type each plant would require. This is easily solved through aeroponics. To implement aeroponics soil is not required. It is the process of providing all the required nutrients for the plants through its roots. The nutrients are provided in a solution form. Basically they are sprayed to the roots. For this we use ultrasonic atomizers. It sprays the nutrient solution equally between the plants and the main advantage is it sprays the nutrient solution with low inertia and of relatively uniform size.

An LCD display is attached with the incubator which shows the current values read from different sensors. It displays the temperature, humidity and light intensity values.

Data for this project is stored on a third-party site called Thingspeak. The data can be viewed in the form of graphs showing changes in humidity, light levels and temperature. A get request is sent from the application every 15 seconds and the data currently on Thingspeak is updated.

Bynk is a new platform that allows your iOS and Android device to quickly build interfaces for controlling and monitoring hardware projects. The android connects via Wi-Fi with Raspberry Pi. Changes made on the application are pushed through the serial port and communicated to Raspberry Pi. The Raspberry PI communicates with serial communication which means that one bit at a time data is transmitted. It is introduced using a standardized asynchronous receiver/transmitter (UART) and is a circuitry unit responsible for the serial contact implementation.

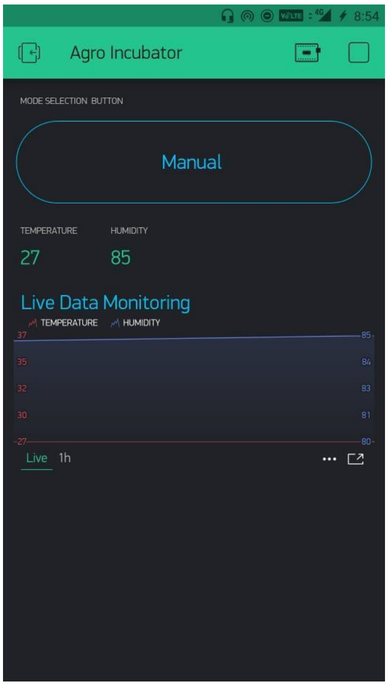

Fig 6.2: User interface of the proposed system

7. PROPOSED SYSTEM DESIGN

The basic working of this circuit diagram includes the input unit that contains the power supply unit and different sensors such as light sensor (LDR) and Temperature and Humidity sensor module (DHT11). Majority of the components make use of a constant 12V power supply. The sensors require 5 and 3.3V which is supplied by Raspberry Pi 4.

The controller unit contains Raspberry Pi 4 and different actuators. The different parameters from the sensor unit are given to the Raspberry Pi 4 and it compares these values with the threshold value stored in the database. If any of the parameters varies from the threshold level corresponding actuators are turned on or off automatically by the controller. The grow light will provide artificial sunlight for plants and the LDR will sense the light intensity level based on the threshold level set inside the database. When the LDR senses light intensity greater than the threshold value then it automatically turns off the grow light. Also, when intensity is below the threshold value then Pi 4 B will automatically turn on the grow light. LDR output is analog in nature and using ADC digital data is given to Pi 4 B. The temperature sensor (DHT11) inside the incubator senses the temperature changes, when the temperature is more than the threshold value then exhaust fan will turns on and brings the desired temperature..Aeroponics is implemented through ultrasonic atomizer An LCD display is attached with the incubator which shows the current values read from different sensors. It displays the temperature, humidity and light intensity values.

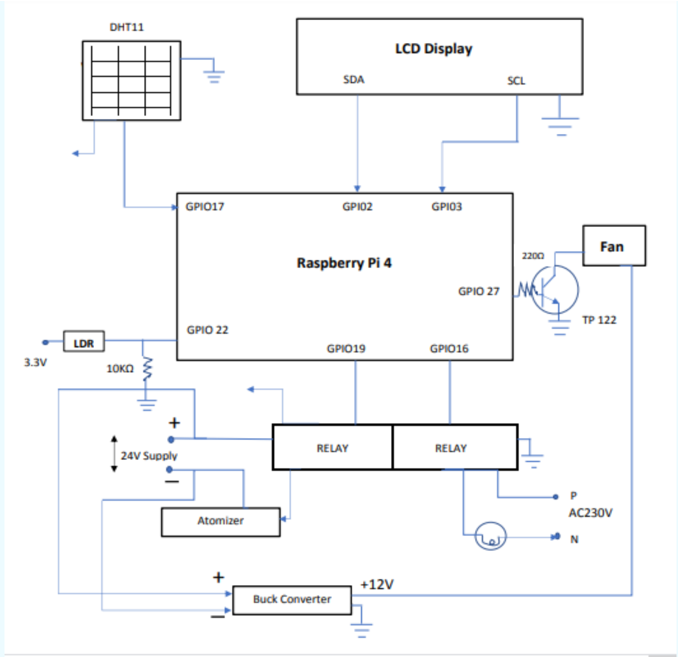

Fig 7.1: Circuit diagram

Bulb is given its supply directly from the mains so it is 220V and the atomizer is 24V. These two components are connected to Raspberry Pi 4 through the relay. Since the fan is 12V a buck converter is used. Transistor TP 122 is used for the control operations in the fan. LCD display is connected directly to the controller Raspberry Pi 4.

7.1 Incubator Box

The incubator contains mainly three blocks. We can call these blocks as block 1, block 2 and block 3. The thickness of each block is 3mm. block 1 is 30cm wide, block2 20cm wide and block 3 15cm wide. Block 1 is the topmost block. It contains four holes. Diameter of each hole is 4cm. The plants are grown in these holes. The holes are kept at a distance of 10cm from each other. That is a hole has 10cm distance with the two adjacent holes. The top side contains the grow light which helps the plants in photosynthesis and provides the temperature required for its growth along with the heating/cooling fan. In the backside of the box there is a door between blocks 2 and block 3. The block 3 contains all the hardware components including controller Raspberry Pi 4. The working of aeroponics process of providing nutrients for the plants using atomizer can also be viewed in the block 2.

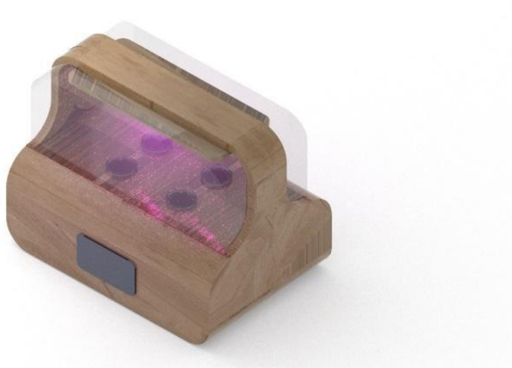

Fig 7.2 Incubator Box

8. DISCUSSION

The result of this project is an easier and more effective means of managing plant growth and enhancing food production and anyone can access high yield of farming. Each plant is provided with the sufficient amount of growing conditions that requires that it helps in producing more healthy and better productive plants. With the aid of different sensors and controllers the farming is made fully automated. If any of the sensed values varies from the threshold value at the database, controllers are automatically switched ON. Android App provides ease of access to the incubator which also helps making the Smart Agro-Incubator remotely controllable.

Name of the plant	**Temperature**	**Water required**	**Type of soil**	**Nutrients required**	**Light intensity**
Cauliflower	17-25^{0}C	200ml /day	Loamy soil	N,P and K	~63000
Apple	7-10^{0}C	400ml /day	Fertile sandy soil	N,K,Mg,P,Ca	~58000
Vanilla	10-30^{0}C	350ml /day	Ca and K rich soil	N,Ca,P,K,Mn and Cu	10000-20000
Tomato	18-28^{0}C	150ml /day	Loamy and sandy loam soil	N and P	25000-50000
Pepper	18-26^{0}C	100ml /day	Loamy soil	N,P,K,Mg	3000-7000
Cardamom	18-35^{0}C	250ml /day	Loamy soil rich in humus	Low to medium P and medium K	5000-20000

Table 8.1: Field Study

9. CONCLUSION

This paper proposes a simple method of automating the greenhouse farming system. The proposed system consists of both hardware and software parts. Raspberry Pi 4 is used for the interface and different sensors are used to detect different parameters inside the incubator and different actuators are used to make the optimum growing conditions. Sensors include LDR, Temperature and Humidity sensor module (DHT11) and the actuators used are Cooling fan, Exhaust fan, Grow light, Ultrasonic Atomizer and Heating bulb. Regular updates can be viewed through the android app. The software part of the project was compiled and concluded using three languages; JavaScript, JSON, PHP for the web server and python for the Raspberry Pi microcontroller. . With the aid of this project, anyone can access high yields of farming and therefore be self-sustainable in the aspect of food production. Once implemented, this system will significantly reduce the amount of manpower or labor required in the day to day management of a greenhouse. A prototype is to be demonstrated, however, to be further developed on a larger scale.

REFERENCES

[2] Susan Nnedimpka Nnadi Francis, E.Idachaba, Department of Electrical and Information Engineering Covenant University Ota Ogun State Nigeria, “Design and Implementation of a Sustainable IOT Enabled Greenhouse Prototype”, International Journal of Scientific & Engineering Research, 2012.

[3] Kshirod Kumar Rout, Samuchita Mallick (IIIT Bhubaneswar, Odisha, India) ,“Solar Powered Smart Irrigation System using Internet of Things”, 2018 2nd International Conference on Data Science and Business Analytics.

[4] Neeraj Khera, Divya Shukla, Shambhavi Awasthi (Asst. Prof., Deptt. of E.C.E, A.S.E.T, Amity Univ., U.P., India), “Development of Simple and LowCost Android Based Wireless Notice Board”, 2016 5th International Conference on Reliability, Infocom Technologies and Optimization (ICRITO) (Trends and Future Directions), Sep. 2016

[5] Retha Dinar Hayu, Riyanarto Sarno, Department of Informatics, Indonesia, “Door Automation System Based on Speech Command and PIN using Android Smartphone”, 2018 International Conference on Information and Communications Technology (ICONTACT).

[6] Muhammad Faizan Siddiqui, Asim ur Rehman Khan, Neel Kanwal, Department of Electrical Engineering National University of Computer and Emerging Sciences Karachi, Pakistan, “Automation and Monitoring of Greenhouse”, 2017 10th International Conference on Telecommunication and Information,Taiwan, 2012.

[7] K. Lakshmisudha Assistant Professor Dept. of Information Technology, SIES GST Nerul, “Smart Precision based Agriculture using Sensors”, International Journal of Computer Applications (0975 – 8887) Volume 146 – No.11, July 2016.

[8] Mary Anne A. Macabuhay, Jeferson N. De Leon Department of Electronics Engineering Don Honorio Ventura Technological State University Pampanga, Philippines, “Smart Household Socket with Power Monitoring & Control using Android Application”, 2017 9th IEEE-GCC Conference and Exhibition (GCCCE),Philippines.

[9] R. Nageswara Rao, B. Sridhar, Assistant Professor Lendi Institute of Engineering and Technology, “IOT based Smart crop field monitoring and automation irrigation system”, Proceedings of the Second International Conference on Inventive Systems and Control (ICISC 2018).