Automated Polyhouse for Optimal Growth of Plants

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Abstract—India has vast area, but current status of agriculture management is not sufficient to provide everything to the population, which can be problematic. The solution to this issue is the practice of protected farming which includes polyhouse farming. The greenhouse covered with simple polyethylene sheet is termed as polyhouse. The function of a polyhouse is to create the optimal growing conditions for the full lifecycle of the plants. The objective of our project is to design a simple, efficient ‘programmable logic controller’ (PLC) based system for automation of polyhouse. The project features monitoring, recording and controlling the values of temperature, light intensity and soil moisture inside the polyhouse. The PLC used is a highly compact, durable and easily available. The values of temperature, light intensity and soil moisture are continuously communicated through various sensors to the PLC. Also, the system uses ‘Supervisory Control and Data Acquisition’ for real time analysis of the process. Proper design, selection, construction and the management of the polyhouse using sensors would augur well to the growth of a crop.

Keywords—Light, moisture, PLC, Polyhouse, temperature

I. INTRODUCTION

Agriculture and allied sectors contributes 16.7% of the total GDP and provides employment to around 60% Indian population. Indian farmers face several challenges such as small land holding, poor yields due to reliance on inefficient methods of farming, too much reliance on natural phenomena such as rainfall and lack of knowledge of modern methods of agriculture. In conventional Agronomical practices, the crops are being cultivated in the open field under natural conditions where the crops are more susceptible to sudden changes in climate i.e. temperature, humidity, light intensity, photo period and other conditions due to which the quality, yield of a particular crop can get affected and may be decreased. Here the concept of protected farming comes into picture. Under protected farming, greenhouse farming is in practice from a long time. But the current system of greenhouse farming in India needs overhaul in terms of technological improvements. To fully exploit the enhanced possibilities for crop and resource management in greenhouses, it is indispensable to perform the adjustment of the control variables in an automatic way.

This is because it is almost impossible for human being to understand and manipulate system with more than two dependent processes without additional aid. Hence the introduction of automatic controllers and computer-controlled greenhouses in the second half of the twentieth century was a major step forward to economically attractive crop production. Even the most basic automatic control will enhance the capacities of the greenhouse industry in emerging greenhouse areas all over the world. There is a need to find balance between the cost of investment that goes into process of cultivation and the returns obtained, at the same reducing the complexity and making the system easily accessible to farmers. One such approach is the practice of polyhouse farming, which encompasses the optimal control of greenhouse cultivation. This asset allows the grower to steer the cultivation in the desired direction.

II. MATERIALS AND METHODS

A polyhouse is a framed structure covered with UV stabilized low-density polythene or other transparent plastic films in which crops could be grown under controlled or partially controlled environment and which is generally large enough to permit a person to work within it to carry out cultural operations easily. It reduces dependency on rainfall and makes the optimum use of land and water resources. Polyhouse farming enables cultivation of crops that can give maximum yield on specific days and exotic crops that can’t be normally grown in Indian conditions.

The polyhouse structure, used for testing the system, is designed in the form of a tunnel. The dimensions are 60cmX50cmX80cm, giving an area of 3000 sq.cm. A 70% UV stabilized polyethylene sheet is used for covering the structure. The area obtained is sufficient for the growth of 4 gerbera plants, which are used for the test. Gerbera is a 30 months crop. The first flowers are produced 7-8 weeks after plantation. The average yield is 200 flowers per sq. meter. It is the fifth most used cut flower in the world. It requires temperature in the range of 20°C-25°C, water requirement is 800ml/plant and light intensity required is around 40000 lux. The system features optimizing three parameters inside the polyhouse – temperature, light intensity, soil moisture.
The PLC takes the conditioned input from these sensors, processes according to the program and then actuates the devices at its output – fan, heater, grow light, and pump. At the same time, real time display of process can be viewed through SCADA. The lock diagram for the overall system is shown in figure 1.

Figure 1 Block diagram

A. Temperature Sensor

Temperature affects the productivity and growth of a plant. High temperatures cause increased respiration sometimes above the rate of photosynthesis. This means that the products of photosynthesis are being used more rapidly than they are being produced. For growth to occur photosynthesis must be greater than respiration. Low temperatures can result in poor growth. Thus, there is need to regulate the temperature for proper growth of plants. The temperature sensor used for the system is based on an NTC thermistor and LM393 comparator IC. It gives a digital output depending upon the status of temperature. It features a potentiometer to set the point at temperature suitable for the plants. The sensor gives a logic 1(+5V) at or below the set temperature (25°C for gerbera) and a logic 0(0V) above the set temperature. The output of temperature sensor is relay driven to be compatible with the PLC logic.

B. Light Intensity Sensor

The plants require a certain amount exposure to light so as to carry out the important process of photosynthesis. Most of the light used by plants is in the visible light range. Red and blue light are the wavelengths of light most extensively used in plant photosynthesis.

C. Soil Moisture Sensor

Plants need large quantities of water for growth. The most important factor driving water movement in plants is a process known as transpiration. Transpiration is the loss of water from plants in the form of vapour (evaporation). Plants utilize most of the water absorbed from the soil for transpiration (95%), but a small portion of the water absorbed is used during photosynthesis for producing the carbohydrates necessary for plant growth (5%). The sensor uses LM393 comparator IC and probes to detect moisture status of the soil. The operation of the comparator is that when the input voltage at non inverting terminal is greater than that at inverting terminal, then the output of the comparator is high. When the soil is dry, the resistance between the two terminals of the probes is very high, thus voltage at inverting terminal would be less than that at non inverting terminal. Due to this the output of the comparator is high. When the soil has fair amount of moisture, the resistance across the probe is negligible, thus the output of comparator is low. The output is relay driven to be compatible with the PLC logic.

D. PLC

A programmable logic controller (PLC) is a special form of microprocessor-based controller that uses a programmable memory to store instructions and to implement functions such as logic, sequencing, timing, counting and arithmetic in order to control machines and processes. The PLC used for the system is Twido series PLC from Schneider Electric TWDLCDA24DRF. The PLC receives the inputs from the sensors and start scanning through the ladder program which is stored in its memory. For temperature control, when the PLC receives logic 0, it indicates that the temperature is high; hence, the PLC produces a signal at its output to turn ON the fan. On the other hand when the temperature is below the set point, PLC receives logic 1, and turn ON the heater. For the light intensity control, the analogue output voltage in the range of 0-10V is received from the light sensor. This is applied to analogue module of the PLC.
When the light intensity is minimal, the voltage obtained is around 9V-10V, this value is above the set point, thus, the PLC turns on the grow light. Contrary to this, when ambient light condition is bright, the voltage output of the sensor is around 1-2V, which enables the PLC to turn off the grow light. For the soil moisture control, logic 0 is received at the input of the PLC for dry condition. The PLC will then actuate the pump to turn it on, thus providing the soil with required moisture. In the event of soil being moistened, the PLC will receive logic 1 signal from the sensor and stop the pump from functioning. The connections for the entire hardware of the system are shown in figure 2. Also the system has provision for diagram in figure 3.

The devices used at the output of the PLC to bring the required parameters under control are: fan, grow light, heating bulb and submersible pump. With the exception of the fan which runs on 24V, other devices need 230V AC for their operation. But, at the output of the PLC digital signal (24V DC) is obtained. Thus, relay drive is used here to provide the necessary voltage to the output devices.

The fan used is a 24V fan; it has a cfm of 114 and rpm 2000. The fan chosen for testing is ideal according to the area (3000sq.cm) of the structure designed for carrying out the test. In order to implement the system on a large scale, heavy duty fans can be used.

The grow light used is compact fluorescent light (CFL); its colour temperature is 6500°K which is ideal for photosynthesis in plants, also light intensity is around 1800 lumens. Red and blue colours of the light promote plant growth.
The heating element used is an incandescent bulb. An incandescent bulb produces 2% light (not useful for plants) and 98% heat. Thus, the incandescent is suitable for use inside the polyhouse. But proper placement of the bulb is essential so that it is at an ideal distance from the plants.

The pump used to supplying the water is a submersible pump which can be immersed inside a tank. It has a pumping capacity of 600 litres/hour, which is sufficient for the field area of the structure used for testing.

F. SCADA

SCADA (supervisory control and data acquisition) is a type of industrial control system (ICS). SCADA systems historically distinguish themselves from other ICS systems by being large scale processes that can include multiple sites, and large distances. Hence, using SCADA, remote monitoring and controlling of the polyhouse parameters is possible. The SCADA used for the system is VijeoCitect from Schneider Electric; which is shown in figure 4.

III. RESULTS AND DISCUSSIONS

As per the system design and the program description, the system would keep temperature, soil moisture and light intensity in the desired range. The system was tested on both the manual and auto mode. Under the manual mode, the switches pertaining to a particular devices can be used to turn it turn them On or OFF. For the auto mode, the PLC comes into the picture and carries out the entire control process by itself. It can be seen from figure 5 the devices which are actuated depending upon the input presented by the sensors to the PLC.

A. Advantages

i. Depending upon the response received from the sensors, PLC gives respective output to control the fans, bulbs, irrigation system without. All this is carried out without any human intervention.

ii. It does not have maintenance issues and can be managed by a single individual

iii. It has the ability to extend growing seasons. Spring can start earlier for germinating and growing seedlings. Fall can extend further to increase vegetable production.
iv. It offers a perfect environment and setup for organic gardening. Plants and vegetables grown in a polyhouse require less pest control than outdoor plants.

v. It offers the most optimum solution for the growth of genetically engineered plants and micro propagated vegetables varieties and hybrids.

vi. The system makes use of SCADA which gives a real time of display of processes being carried out inside the polyhouse in the form of graphics, thus making it a user friendly interface.

vii. Natural resources such as water, soil are used judiciously, thus preventing their unnecessary use.

viii. Malfunctioning of a single sensor will not affect the system much, as provision are be available to maintain the system parameters at least near limits through natural phenomenon.

B. Disadvantages

i. Although, pest control required is a lot less as compared to traditional methods of farming, but complete automation in terms of pest and insect detection and eradication cannot be achieved.

ii. Requires uninterrupted power supply.

iii. Winter time requires more heating which increases power consumption.

III. Conclusion

The system so developed has the ability to monitor and control the temperature, light intensity and soil moisture within the required limits. This is done through the use of sensors and the actuated devices. It is imperative to get correct placement sensors to get maximum climate control which is vital to the success of any indoor crop. The system can be used to grow plants in extreme weather conditions, since indoor climate can be automatically controlled. The project overcomes few shortcomings of the existing system by striking a much needed balance between the cost of investment and the returns. The project has a huge scope for further research and development. Polyhouse farming is an emerging farming technique and there is need to create awareness about its benefits which can go a long way in making the country self-sufficient.

REFERENCES


Figure 5 System working in auto mode