Intelligent In-House Mini-Automated Farming

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Abstract—Fresh Green consumption is increasing everyday due to large population growth and this requires fertile area to cultivate, energy-to maintain and transport these developed crops to the consumers. It also requires water to grow the crops from germination to the harvesting stage. An intelligent In-house fully automated farming cabinet has been designed and fabricated which is ready to put into practice in the Middle East region and in regions where it is extremely difficult to grow fresh herbs due to unfavourable climatic conditions. The product is also capable of growing and maintaining the crops completely automatic without any effort by the user. User without any prior knowledge in knowing how to grow these vegetables can grow herbs/vegetables right in the kitchen without the use of any chemicals/pesticides. The fabricated cabinet (or product) comprises of hydroponic systems, artificial grow lights and automation systems. User friendly design has been accomplished in terms of smart automated system to control the stages from germination to harvesting and in maintaining the parameters at optimum conditions. The developed system is capable of maintaining pH, and Electric conductivity (EC) of water, Humidity, temperature and right light spectrums to grow crops in the cabinet as per the required standards. Programmable Logic Controller IL1 ETH 2TX module is used and this controller is programmed using PCWorx software. Human-Machine-Interface (HMI) Touch panel is utilised to interact with the machine. Using this cabinet, six different types of herbs were grown by consuming approximately seven liters of water a month.

Index Terms—artificial grow lights, automation, farming, Human Machine Interface (HMI), Programmable Logic Controller (PLC)

I. INTRODUCTION

Every community in this planet needs comfortable living environment. Good living always starts from healthy food habits and one way of achieving this is by growing vegetables/herbs for our day to day needs without the use of chemicals/pesticides that can cause harmful effects. Most of us who live in big cities have the constraints such as space limitations and extremely occupied with jobs having no time to cultivate and maintain vegetables for themselves or the entire family nor does the majority of people have the knowledge to grow and maintain these vegetables.

The novelty of this paper is about improving the standard of growing vegetables in terms of texture, aroma and taste. The prototype product is designed and developed to grow and maintain the crops fully automatic without any effort by the user in the kitchen without the use of any pesticides. Vegetables processed with chemicals or pesticides are one of the main cancer causing agents and they are not just responsible for cancer but a list of other related diseases.

Figure 1. Block schematics of the prototype product

Hydroponic technology has been used in this project. Hydroponic system is a method of growing crops using mineral nutrient solutions in water without the use of soil. Authors have concluded that hydroponics is an efficient technology for growing plants [1]. Previous research studies have proved that herbs have a tremendous potential to grow 25% faster than usual with hydroponic systems [2]. Although hydroponic concept is not new, a very little research has been done in combining the hydroponic technology with artificial lighting and automation systems. Our work on intelligent in-house mini-automated farming described in this paper is a combination of three sub-systems namely hydroponic system, artificial grow lights and PLC based automation systems as shown in Fig. 1. Artificial grow lights which depict the similar light wave lengths aids photosynthesis for the plant. The research concluded that the irradiance spectrum to which plants are exposed has specific effects on different type of plant responses such as photosynthesis, photomorphogenesis [3]. The other researchers suggested that specific parts of the spectrum are involved in sun and shade light responses of plants [4], [5]. Researchers have reported the use of automation and advanced technologies in Agriculture [6].

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In this work, automation system is designed and programmed to control the entire process for maintaining parameters such as pH and EC of water, Humidity, temperature and required light spectrums for optimum grow conditions of the crops and create a smart interface to interact with the controller.

II. METHOD

The proposed work consists of a combination of systems such as the Hydroponic system which is a clean modern farming technic, artificial grow light system used to depict the right spectrums for plants to grow and last is the automation system which consists of a controller block to automate the necessary parameters with a HMI-touch panel to interact with the user and the entire process.

A. Hydroponics

Hydroponics is a subset of hydroculture and is a strategy for developing plants utilizing mineral supplements arranged in water, without soil/dirt being the medium/substrate to grow. Physical plants may be developed with their roots in the mineral supplement arrangement just hanging or in a dormant medium, like the perlite or gravel. Fig. 2 explains the hydroponic system [7].

![Figure 2. Simple working of water cycle for hydroponics](image)

The apparatus consists of the flood tray which holds the water for a short time, the grow tray which holds the plant and the substrate, the water reservoir which consists of the water solution which is pH controlled and nutrients are added. With the help of a pump in the water reservoir the water is circulated from the reservoir to the flood tray and the water is held in the flood tray on an average of five minutes. The frequency of this process usually depends of factors like humidity of air where the plants are present and the surroundings temperature.

The pH value of water is maintained between 5.5pH to 6.5pH which is the recommended pH range to grow herbs. EC has to be checked in order to add the grow nutrients to the water reservoir to help the plants grow. On the initial stages of the plant growth 0.9 to 1.0 EC has to be maintained. A combination of coco peat and perlite in the ratio of 1:1 is used as substrate to grow herbs in development of this product.

B. Artificial Grow Lights

A grow light or plant light is a counterfeit light source, usually in most cases an electric light, intended to simulate plant development by emitting a light spectrum range which would be most suitable for photosynthesis. Grow lights are used for cultivation, indoor planting, plant engendering and nourishment, including indoor hydroponics and aquaponics.

C. Light Spectrum for Photosynthesis

Plants absorb vitally from the red and blue spectrums of the two ends of the entire light spectrum. For full photosynthesis by the plant it is essential to have 400 to 450nm of wavelength and 600 to 650nm of wavelength while the other ranges of the spectrum are not at all useful for the photosynthesis process as shown in Fig. 3 [8]. Green light is at the center of the light spectrum which is nearly 500 to 530nm of wavelength and the plant reflects it which makes it appear green to the human eye. In order for photosynthesis to take place the plant absorbs light through the pigment called chlorophyll. Chlorophyll has its greatest absorption at 430nm and 660nm.

![Figure 3. Plant responses to light spectrum](image)

D. Automation

The automation for this project was done using Phoenix Contacts modules in terms of PLC and HMI. The ILC 171 2TX PLC module is used to automate the system [9]. The ILC 171 ETH 2TX module is a small-scaled controller which is put to use in the case of the Inline Input/Output (I/O) system which is the main point for easy Automation. The ILC 1X1 series is defined by its support for the Modbus/TCP and PROFINET Ethernet-based communication. Another peculiarity is the backing for a discretionay Secure Digital (SD) card.

The HMI was developed using a web based Touch panel which could communicate through PROFINET. The required Internet Protocol (IP) address had to be fed in to retrieve the graphical data from the controller. Fig. 4 shows the schematic diagram of the Automation systems used to design and fabricate the prototype model.
III. RESULTS

Fig. 5 shows the product which is designed, automated and fabricated. It has three shelves capable of housing six trays to grow six different types of herbs. Fig. 6 shows the panel wiring diagram.

- The prototype was designed and built from the scratch where in which the herbs were grown as in Fig. 7. Using this prototype one can grow six different types of herbs or basic vegetables of the user’s choice, completely automatic. Wheat grass, Basil and coriander and mustard sprouts were grown successfully in United Arab Emirates (UAE) during the summer season. Approximately seven liters of water was used per month to grow six trays of herbs mentioned above.

- In order to conserve water, water is reused in the entire system.

- In order to improve the user friendliness of the system for the people who lack the agricultural knowledge, additional provision has been incorporated in the touch panel to select the required settings such as the watering cycle, lighting cycles and humidity for growing different types of herbs in the cabinet.

- The following plants as in Fig. 8-Fig. 11 were grown without the use of any pesticides or chemicals and completely automatic without any effort by the user.
The benefits are freshness, better taste and smell and no chemicals added.

- Ladder logic schematics for the ‘main function’ to start the machine, controlling grow lights, logic for controlling the water cycle for each level are depicted in the Fig. 12, Fig. 13 and Fig. 14 respectively. The programming was executed using PC worx software [10] for automating the controller.

- Eight different HMI screen views were developed using webvisit software and displayed on a touch panel WP-06T [11], [12]. Three such screen shots are depicted in Fig. 15, Fig. 16 and Fig. 17.

- To enhance the user friendliness of the system, grow setting provision has been made which has predefined configuration for lighting and watering cycles for the herbs listed. Fig. 18 shows the screen shot of grow settings.
The mission and vision of the product developed and described in this paper is to integrate already available technology with modern clean farming techniques for people who lack the knowledge to grow but are in need of these green crops. This prototype has been designed for catering a small group of people which can be placed inside a kitchen for a family of five people to serve fresh herbs/vegetables. The project can be up scaled up and modified as per the following proposals:

- With the similar mechanism, a setup can be assembled inside a 40 feet container or in air tight rooms to grow vegetables for a larger community located in regions of harsh weather conditions.
- Integration with solar panel to improve the energy efficiency.
- It is totally portable unit and is most suitable in regions where there is food scarcity.

IV. CONCLUSIONS

The authors wish to thank Phoenix Contact, Germany and Phoenix Contact, Middle East for sponsoring 3,000£ worth automation modules to successfully complete this project and fabricate the fully automated cabinet. We would also like to thank the Juries of the “Xplore Automation Award 2015” for nominating and awarding 2nd place in the Environmental category.

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