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IoT Based Automated Hydroponic Cultivation System

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Abstract— High yielding and high grade of crops are essential in modern day agriculture, this can only be achieved by smart farming technology which is used for making farms more intelligent in sensing its controlling parameters. Manual monitoring is in practice which is a very trivial task because the plants may die out if there is no proper care is taken. The architecture of this hydroponic system which is fully automatic that can be integrated into the agricultural curriculum while introducing business skills. The automatic monitoring and control of the environmental events such as light intensity, pH, electrical conductivity, water temperature, and relative humidity is carried out by lodging sensors and actuators onto the system. The maintenance and automated monitoring are done by the intervention of the IoT that are used to transfer and retrieve data to the internet (mass storage) and a mobile app is used to communicate the current status of the hydroponic system to the user through the use of internet to their mobile phones. This futuristic system can use high data analytics and prolonged data gathering to improve the accuracy of reckoning.

Keywords— ***IoT, Hydroponics, Automation, digital image processing, sensors***

I. Introduction

Hydroponic is a method where the crops are grown in the absence of soil the nutrients that are acquired from the soil are given to them artificially. The term Hydroponics was acquired from the Greek words ‘hydro’ means water and ‘ponos’ means labour. This soil less culture of originating crops often involves their roots to be immersed in the nutrient solution along with some gravels or perlite medium. The maximum yield is achieved by the supply of sufficient quantity of nutrients and optimum microclimatic conditions are the main goal of hydroponics. Since soil is excluded from production process there will not be any problem related to soil borne diseases, pests and weeds. By the exclusion of these problems, there will not be any usage of harmful plant protection chemicals, so that there is a fresh and healthy yield of crops by the hydroponic method. The set-up of hydroponic only demands limited space and limited quantity of water as they recirculate and reuse the water. This eliminates the problems that are caused by soil. This limited space requirement also favours hydroponic as it can be accommodated in terraces, balconies and courtyards. So, there is a high probability of growing crops in urban areas, where cultivable land is limited. Hydroponics does not cause any adverse effect on the quality of fruits and flowers produced by it.

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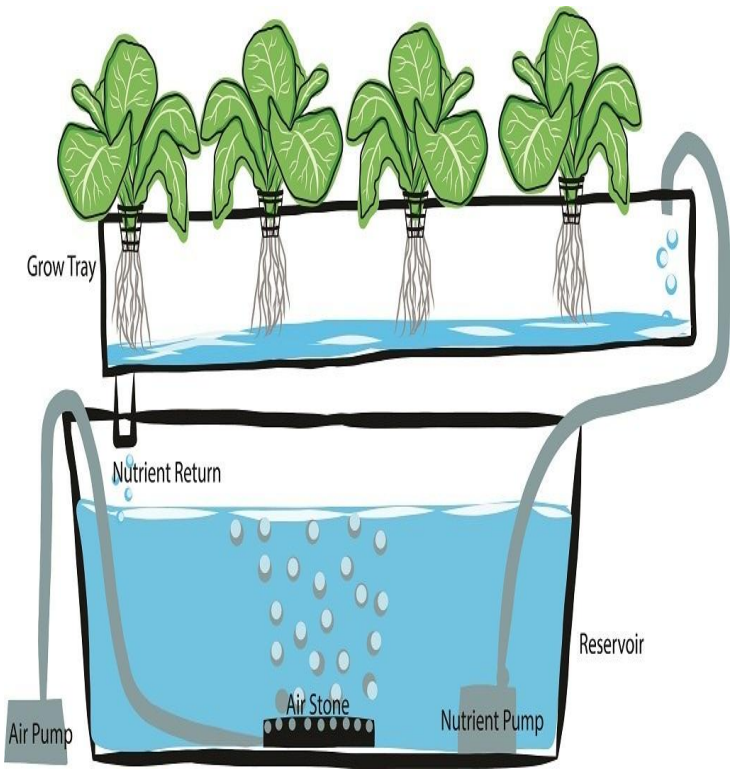

Fig.1 General Hydroponic Setup

II. Literature Survey

Hydroponics or soilless cultivation has been widely used in different countries because of its feasibility and environmental safety. This technique can be considered as the best alternative in areas where serious soil and water problems like soil born pests and diseases, soil and water salinity, chemical residues in soil and water, shortage of water etc. exist. In hydroponics, plants are grown by directly supplying optimum amount of nutrients in water. Composition of nutrient solution, electrical conductivity, pH and oxygen concentration have direct influence on the yield and quality of crops grown under hydroponics. If any of these factors are non-optimal, crops expresses stress symptoms.

The yield of tomato cultivars Turquesa and Carmello increased by 32 per cent and 21 per cent respectively when grown under NFT using Cooper's nutrient solution [1].

A research carried out by Maritsa Vegetable Crops Research Institute, Bulgaria, proved that the tomato cultivar Lucy produced more vegetative growth and better yield in Cooper's solution than Plantan solution under hydroponics [2].

The potassium in the nutrient solution affected the pigment concentrations and beta carotene content of tomato fruits in hydroponics [3].

In a study the effect of nitrogen and salinity levels of nutrient solution on the fruit yield and chemical composition of tomatoes under hydroponic culture proved that nitrogen concentration and salinity levels in the nutrient solution gradually increased the vitamin C content of tomato fruits [4].

With increase in nitrate ratio to urea in the nutrient solution, the yield of tomato in Nutrient Film Technique (NFT) increased by 25 per cent [5].

When nitrogen and potassium were added at a concentration of 177.2 and 188.7 mg/l respectively in hydroponic nutrient solution, the size of tomato increased, stating that in nutrient solution N and K should be in the ratio of 1:1 [6].

Cucumber seedlings showed good growth results (healthy appearance, high biomass and high photosynthetic activity) when grown hydroponically by supplying Hoagland solution under LED light [7].

On the supply of different nutrient solutions, observed that there is a qualitative trait in lettuce, Hoagland solution was the best in hydroponics [8].

The effect of levels of N, P and K on the dry matter production and mineral nutrition of hydroponically grown green onion cultivar 'Todo Ano" (*Allium fistulosum* L.) [9].

Nitrogen fertilization in hydroponic cultivation of tomato, proved that, the reduction in nitrogen concentration (11, 9 and 7milli eq. nitrogen/l) did not decrease the tomato production and it did not make any significant variation on the diameter and dry and wet weights of tomato [10].

In a study on the potassium level, physiological response and fruit quality of hydroponically grown tomato showed that the addition of potassium at the rate of 300 mg/l to the hydroponic media improved the plant growth, yield and quality of tomato. The addition of potassium directly influenced the postharvest preservation and processing [11].

All the study mentioned above deals with hydroponics system with manual processing and monitoring which gives less yield and efficiency. Nutrient mixing is the important aspect of the system which directly affects the plant growth. Maintaining and controlling the nutrient mixer manually is a tedious process and may lead to human errors which will affect the overall yield. Our proposed system is an automated system which will overcome the disadvantages of the previous system.

III. System and Design

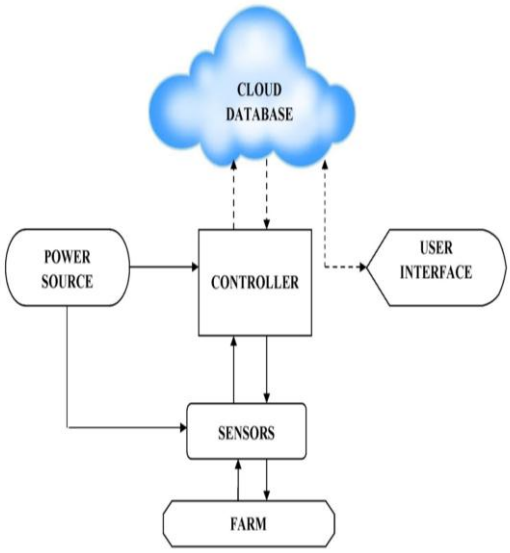

Fig.2 Block Diagram

The IoT plays a major role in the automation process. Automating this hydroponic system is the most crucial part, this can be easily achieved by integrating the hydroponic system with the IoT. Cloud database acts as the hub for the whole automation process, this database contains all the information on the hydroponic system that is it has the information on the data that has been retrieved from the crops and the water tank.

Sensors and actuators are used in order to automate the hydroponic system, these sensor values are sent to the cloud database from which the user is updated with the real time information about crops condition. The user can also adjust the configuration of the sensors and actuators from the developed mobile application.

The mobile application has all the specification about the hydroponic system, the user must have a unique login ID. The user name and the password are registered with the cloud database, by this the user can operate with his crop field without any interruptions. Through this mobile application the user can select which seed are to be planted in the crop bed, the water flow can also be controlled with the help of this mobile application. The user can control the flow of water from one tank to other tank with water level sensors and solenoids.

The captured image of the plants are uploaded to the cloud database in this way the user can verify the health condition of the plants. If there is any health issues with the plants, the user can control the nutrient tank to let more nutrients to the crop bed, by this way the plants can be grown without any health issues.

IV. Methodology

The seed of the desired crop is used and placed in the crop bed in phase-2 manually. A domestic power source is used to power the system. The user can select the crop that is to be planted from his mobile application which is connected through IoT.

After the crop selection is done, the water is pumped from the main tank to the automatic nutrient mixing tank, the water pump stops pumping once the water level is reached. Here the water is mixed with the nutrients inappropriate proportions according to selected crop. After the completion of this process the user is notified through the

mobile application. Users can also see level of nutrients present in water through his mobile application.

The nutrient rich water is then flowed through pH tank with the help of solenoid valve. The user is notified once the pH tank is filled with the nutrient rich water. The pH tank has a pH sensor which monitors the pH of the water. If the pH of water is undesirable, then the system sends an alert to the user that pH is not in correct proportion and asks the user to enable the solenoid valve S2 with 'YES' or 'NO'. If the answer is 'YES' than the solenoid valve S2 opens and the water is poured out to reuse tank. If the pH of water is in correct proportion then the water is oxygenated by the oxygen pump. Once the water is completely oxygenated the user gets notified that pH is OK and water is oxygenated and ready to flow to the plants.

Water pump P2 is used to pump water to the plants as well as from the plants by this way the water is circulated. The temperature and humidity of the environment is measured by temperature sensor and the readings are shown in the mobile application.

Normally a camera is used to monitor the growth of the plants and also looks for any infection on the plants, these processes are updated to the user through the mobile application. Once the plants are ready to harvest, system sends the notification, your plant is ready to harvest. If the camera spots any infection in plants due to insects or disease, this turns the system into red alert by sending the red alert message to the user via application.

Here digital image processing is used to point out the infection on the plants, the user is notified once the infection is detected. The system compares this image with the data in the cloud. If the symptoms of the image taken with the existing data are similar, then the system identifies the name of the disease or insect that has infected the plant and sends the complete details about the infection with its cure to the user via application.

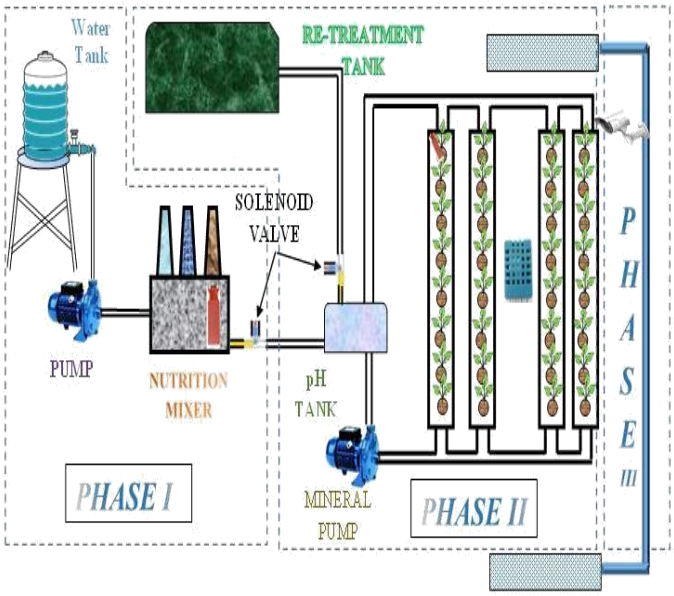

Fig. 3 Schematic Diagram

Fig. 4 Hardware Setup

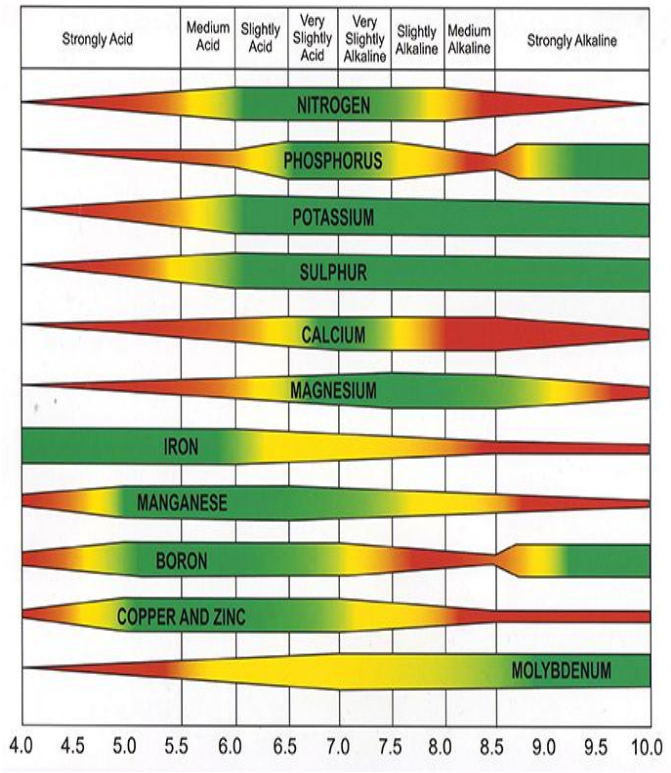

Fig.5 Plant Nutrient and pH Levels

V. CONCLUSIONS

In this study, the crops are grown without the use of soil, instead the nutrients from the soil are directly given to the crops by water reservoir. The adequate

nutrients that are required by the plants are measured and added to the water reservoir so that the crops get enough nutrients from the water as equal as from the soil. By the intervention of IoT this whole hydroponic system can be automated. All the data from the hydroponic system are sent to the cloud data for the automation purpose. A mobile application is developed for the user to get notified of the progression of the crops growth. The user also gets information about the hydroponic system with the help of the mobile application. The health condition of the crops is continuously monitored with the help of data that are collected by the sensors and actuators. The digital image processing identifies if there is any infection or disease spreading in the plants and notifies the user through their mobile application. Thus, this hydroponic system can be adopted in any environmental conditions and it is a fully automated setup that can be operated through a mobile application.

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