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IoT based Plant Monitoring System for Hydroponics Agriculture: a Review

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Abstract*: Cultivation, integrating up to a paramount aspect in GDP, has been affected tremendously over the past few decades due to the utilization of chemicals. Due to rapid urbanization and industrialization, arable land under cultivation is decrementing enormously. Organic farming, being the desideratum of the hour, is opted as one of the widely chosen methodology to surmount the prevailing problem in cultivation. Advancements in agriculture have proven to accommodate the cultivators in a number of ways. Cultivation of crops is being done at home, which consumes constrained amount of space and cost. To bring in another technological advancement by breaking all barriers, for organic farming is the Hydroponics where consumption of space and water are way too minimal. Hydroponics is a method of growing plants pristinely utilizing water and nutrients, without soil. The proposed hydroponic system is built upon the concepts of embedded system. The system facilitates the magnification of multiple crops under a single controller. Compulsory supplements for the crops are provided predicated on the inputs obtained from the pH sensor and the water level sensor utilized. The water and nutrient supply to the different varieties of crop is controlled and monitored at customary time intervals. An efficient algorithm has been proposed for controlling all the functionalities. Automation of the hydroponic system amends the efficiency and reduces manual work.
***Keywords*: Hydroponic, embedded system, organic farming, IoT, deep water culture.**

I. INTRODUCTION

Food being the basic primary requisite worldwide for leading an energized and salubrious life must be abundantly cultivated and made available. This production is carried over by the technique called cultivation. Agriculture facilitates in providing the most essential commodity required for a living which is victuals. A number of vegetables, fruits, nuts and spices are all perpetually being cultivated through various techniques. Each crop is grown in a different environment requiring a wide range of essentials, depending upon the crop's genetic organization. Chemical fertilizers which are considered to be hazardous for mankind are profusely utilized in the present day farming. To surmount this, an environment amicable approach has been adopted called the organic farming [1]. To cerebrate upon with the perspective of considering human health as the at most consequential factor, organic farming needs to be implemented all over the world. Incipient techniques and a variety of approaches are required to be implemented in order to achieve this organic way of cultivation. One such prominently used organic farming technique is the Hydroponics. Hydroponics mainly involves the cultivation of crops without the utilization of soil and chemical fertilizers, which relaxes the threat of pest attacks and other crop diseases. The nutrients required for the plant magnification are supplied in the form a nutrient solution with a concrete cumulation of required components depending on the plant's need. The system is built in a closed environment as the crops grown in here have the potential to nurture without sunlight.

This in turn obviates the algae formation in the nutrient solution which the crops are prone to. The current hydroponic system can be used to grow multiple crops simultaneously. But then it requires the utilization of all the indispensable components of magnification independently. Additionally these systems are made to work on a concurrent substructure. Although this amends the performance, it lacks integrity. We have adopted a technique to overcome these with logical grouping of resources and prioritizing their requirements and needs [2].

The main objective of hydroponics is to supply the ideal nutritional environment for optimum plant performance. Although technically not a portion of hydroponics, growers typically try to provide ideal environmental factors also. Plant performance may be further optimized by controlling the climate and lighting along with the development of protocols and assessment of the relative stability for the evaluation of cultivars of leaf, fruit, space and seed yielding specialty vegetables, herbs and spices, and to determine the factors affecting the adaptation of sustainable hydroponic culture under CEA systems in both aggregate and liquid-culture hydroponic system developing the nutrient management strategies for optimizing nutrient-use efficiency of fruits, vegetables, and to minimize nutrient losses through run-off from open-loop hydroponic systems.

II. RELATED WORK

The conception proposed by Saaid et al. [1] implements one of the hydroponic system models which is Deep dihydrogen monoxide culture. In this model roots are submerged in nutrient and oxygen opulent dihydrogen monoxide. pH sensors are being used to monitor the nutrient content in dihydrogen monoxide .In this paper, automatic control action is taken to control the pH level with the help of microcontroller which is measured with the help of sensor. In this research the change in the pH level when it is starting to change as well as the change in the effects of pH adjuster solution to the water solution are determined. This paper also focuses on the ability of the system that can adjust the pH value in water solution for the deep water culture technique. The water solution from the DWC container is transferred to the major tank to measure the pH level by sensor and make the adjustment if necessary and then it is transferred back to the DWC container to grow the plant. The result from the experimental test showed that the system is able to decrease the pH level by 0.58 pH level and increase the pH level by 1.15 pH. The system proposed by Lenord et al. [2] presents an efficient system controlling the hydroponic nutrient solution by utilizing genetic algorithm and optimizing the system parameters. To access the quality of solution utilized, a Mamdani fuzzy interference system utilizes a set of parameters as its fitness function. Light is considered to be the main factor influencing plant magnification. The fuzzy interference evaluation system has been designed using expert opinion from researchers at Murugappa Chettiar research centre in India.

To evaluate the performance of proposed algorithm a virtual hydroponic nutrient control system with a solution monitoring unit was designed. The designed algorithm demonstrated better convergence efficiency and resource utilization compared to conventional error function based nutrient solution control system. Rongsheng Chen et al. [3] discusses about the magnification of lettuce and how light affects it in the hydroponic system. Red light was utilized as an enhancing parameter to stimulate the magnification of shoot and root. And it was recorded that the magnification incremented with a raise in intensity of red light. In this research the lettuces were grown for 35 days under different light treatments. From the experimental test results it was observed that both the growth and quality of lettuce were significantly affected by light quality treatment where the growth was enhanced by red light and increased even more as the quantity of red light increased respectively.

This research concluded that the contents of soluble sugar and vitamin C as well as the soluble sugar concentrations in lettuce increased under red light and the nitrate concentration was decreased thus concluding that more red light is benefit for the growth and quality of lettuce in hydroponic. The system proposed by Saaid M.F et al. [4] is predicated on Aquaponics which is nothing but the collaboration of hydroponics and aqua culture. Arduino programming is utilized to obtain information from the sensors and process the indispensable output back. In particular, the magnification of goldfish is studied. In this research the growth performance of comet goldfish against a hydroponic plant of Ipomoea aquatic, Spinacia Oleracea type of leafy vegetable and water plant were evaluated in recirculation of this Aquaponic system towards temperature, light and fish waste effectiveness. In this system the fish were feed with commercial pelleted feeds containing 30% crude protein that provides all the nutrient required for the growth of plant. To maintain the growth and survival rates auto-feeder system are used. Also the set point is calibrated to control and monitor the temperature in fish tank as well as the temperature surrounding the plant area. Hydroponics along with aquaculture is a self-feeding mechanism. This sustainable method can be implemented in individual homes as well as in a large scale level. These methods can considerably make organic farming an easy and routine process at homes. The above implementations have potential possibilities for finding solutions to meet growing food demand in the near future. A simpler integration and leverage is needed to make these techniques feasible for common people and farmers in the market.

III. PROPOSED SYSTEM

The magnification environment differs for each and every crop predicated on the morphological and genetic structure. The proposed work deals with integrating the growing environment for individual crops on to a single system. A well-organized setup is built for the smooth functioning of the system. Appropriate nutrient solution is supplied to the crops, mixing them with the required quantity of water. Various sensors are utilized for monitoring the pH level of the nutrient solution and the water level. The input obtained from these sensors will enable the controller to regulate the water and nutrient flow in correct proportion. The controller is programmed with an efficient algorithm which will systematically regulate the flow.

The system once built is tested upon for meeting an individual crop's requisite and then all of which are integrated. This integrated system will improvise the magnification of crops rapidly.

The soul of this system is the controller which enables the entire functioning. Processor performs all the control actions necessary for the system. pH meter and water level sensors are used for calibrating the appropriate measurements needed for the plant growth.

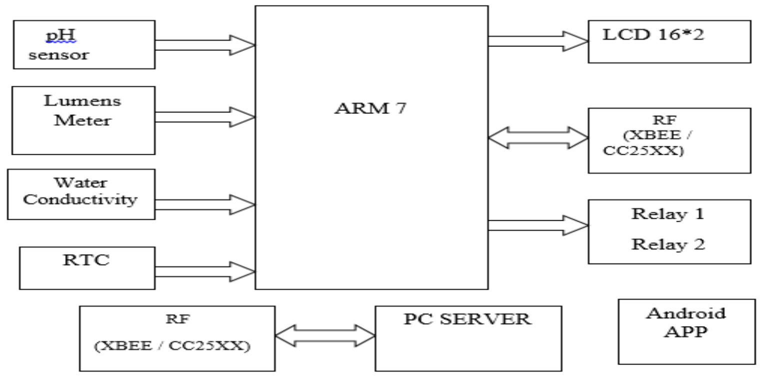

Figure 1. System diagram of Hydroponics

The system is formulated by initially building up a setup for a well-organized flow and functioning. This is essential as there are number of aspects that govern the growth of plants. Not only the saplings and nutrients would suffice the growth, but a well-constructed environment is essential for the proper growth and nourishment of the plant. As shown in the above figure the brain of this plant health monitoring system for hydroponics agriculture is the controller that enables the entire functioning of various parameters responsible for the growth of the plant. The microcontroller will continuously monitor several environmental conditions such as water pH, water conductivity and luminosity to achieve the optimal growth of the plants [6].

In hydroponics the plants need to be kept at a specific pH value (typically 5 to 5.5). The water that we get in the tap does not have suitable pH value. The pH value has to be constantly monitored on daily basis. Altering the pH affects the photosynthetic activity of the plant and the maximal growth of the plant can be achieved by increasing its pH. High temperature and high light intensity in summer season tend to induce unbalance water uptake and mineral elements in hydroponic cultured plants. In addition, differential uptake of various elements causes unstable pH in root zone. To solve this problem the best managing range of nutrient and pH nutrient solution is necessary. The water conductivity is also monitored which affects the absorption rate of nutrients by plants. Proper conductivity level leads to the maximum growth and yield of the plant. It is kept at a certain given set point.

Giving lights to the plants is another major factor. Each plant light requirement is different than others. The ambient light is measured using the luminosity meter which give output in lumens.in hydroponics agriculture system the plants need to be kept under light for 16 hours and in the dark for 8 hours to get maximum yield. For this the inbuilt RTC function of the controller is used throuh which the lights will turn ON/OFF every 16 hours and so on.

The android app developed for this system will monitor and control the hydroponics plant growth from anywhere using IoT. A graphical representation of plant growth will be drawn on the server for manipulations and analysis of the plant growth and for effective control of plant growth. In the output window there will be a provision to see all the database growth in the form of a report generated in Excel file so that we can compare the methodology offline and the data can be used at any time in the future whenever necessary for analysis of the system. The output readings of the various parameters that are taken while controlling and monitoring of the plant are displayed on the liquid control display consisting of 16 rows and 2 columns. Relays are used for controlling the ON/OFF action of the system.

IV. CONCLUSIONS

Soilless cultivations are becoming increasingly consequential and now appear as the most promising for space applications. In fact, the possibility of not carrying soil, is winning during a space travel for the reduction of weight and for the reduction in the volume occupied on the vessel, but additionally for the incipient geometries in the situating of the plants, certainly more imaginative than a traditional crop, that sanction to further manage better the space on board. A major breakthrough is required in the farming practices through technology aided organic farming. For the modern era a reliable way is open for productive organic farming practices through the adoption and advancement in technology. Pesticides and modern fertilizer usages have lead to various health hazards. Plant and food quality is being in a state of degradation day by day. Personal or home farming practices have to be emphasized, practiced and must be supported in various manners. The proposed hydroponic system implements the integration of different types of sensors controlled through automation for the maximal growth of the plant. The effect of various environmental parameters such as salinity, oxygenation, electrical and water conductivity, pH has been monitored. A methodological approach has been taken forth to regulate the working of the system. The plant growth under soil and soilless culture will be analysed thus concluding the efficiency of the hydroponics system. From its characteristics, the system is a strong candidate for space application as well as for the cleaner nutritive yield. The smart indoor organic farming in the near future will have the prominent and potency to feed the whole world.

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