Integrating Scheduled Hydroponic System

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***Abstract*— Cultivation, adding up to an important aspect in GDP (Gross Domestic Produce), has been affected tremendously over the past few decades due to the use of chemicals. Due to rapid urbanization and industrialization, arable land under cultivation is decreasing enormously. Organic farming, being the need of the hour, is opted as one of the widely chosen methodology to overcome the prevailing problem in cultivation. Advancements in agriculture have proven to serve the cultivators in a number of ways. Cultivation of crops is being done at home, which consumes limited 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 purely using water and nutrients, without soil. The proposed hydroponic system is built upon the concepts of embedded system. The system facilitates the growth of multiple crops under a single controller. Necessary supplements for the crops are provided based on the inputs obtained from the pH sensor and the water level sensor used. The water and nutrient supply to the different varieties of crop is controlled and monitored at regular time intervals. An efficient algorithm has been proposed for controlling all the functionalities. Automation of the hydroponic system improves the efficiency and reduces manual work.**

Keywords—*Hydroponics; fertilizers; water flow; controller; crops; nutrients*

I. INTRODUCTION

Food being the primary requirement worldwide for leading an energized and healthy life must be abundantly produced 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 food. A number of vegetables, fruits, nuts and spices are all constantly being cultivated by 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 used in the present day farming. To overcome this, an environment friendly approach has been adopted called the organic farming. To think upon with the perspective of considering human health as the at most important factor, organic farming needs to be implemented all over the world. New 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 use of soil and chemical fertilizers, which relaxes the threat of pest attacks and other crop diseases. The nutrients required for the plant growth are supplied in the form a nutrient solution with a specific mixture 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 prevents 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 usage of all the necessary components of growth independently. Also these systems are made to work on a concurrent basis. Although this improves the performance, it lacks integrity. We have adopted a technique to overcome these with logical grouping of resources and prioritizing their needs.

In this paper, existing works related to hydroponics and Arduino programming are presented in section II followed by a description of the proposed system modules in section III, also an algorithm devised for maintaining the flow of control has been included. Further the system's performance has been analyzed and compared with the existing system in section IV.

II. EXISTING WORK

The idea proposed by Saaid et.al. [1] implements one of the hydroponic system models which is Deep water culture. In this model roots are submerged in nutrient and oxygen rich water. pH sensors are being used to monitor the nutrient content in water. The system proposed by Lenord et.al. [2] presents an efficient system controlling the hydroponic nutrient solution by using genetic algorithm and optimizing the system parameters. To access the quality of solution used, a mamdani fuzzy interference system uses a set of parameters as it's fitness function. Light is considered to be the main factor influencing plant growth. The idea proposed by

Rongsheng Chen et.al. [3] discusses about the growth of lettuce and how light affects it in the hydroponic system. Red light was used as an enhancing parameter to stimulate the growth of shoot and root. And it was recorded that the growth increased with a raise in intensity of red light. The system proposed by Saaid M.F. et.al. [4] is based on aquaponics which is nothing but the collaboration of hydroponics and aqua culture. Arduino programming is used to obtain information from the sensors and process the necessary output back. In particular, the growth of goldfish is studied.

In addition to these existing works on hydroponics, few other works on the usage of Arduino board and programming certain applications were referred to. L. Buechley et.al. [5] has proposed and formulated a toolkit for e-textiles which is trending in the past few decades. It enables the users to design their own unique design and build their own e-textiles. In the system proposed by M.S. Perez et.al. [6], time synchronization is validated experimentally for real systems like Bluetooth communication channels. The system is implemented in an Arduino based network, for which acoustic events are considered to be of at most importance. The idea proposed by T. O. Loup et.al. [7] is to build a room-safe security system with the help of embedded system. Here the temperature is considered and a threshold value is set. Once the temperature exceeds safety levels, a message is sent via Bluetooth for security reasons. The idea proposed by A. A. Murthy et.al. [8] describes the functioning of the electric guitar where in the distortion effects are mainly considered. Arduino UNO board is used for measuring and analyzing this effect in guitars. This is one important effect that is found in all the musical instruments.

Compared to all the existing works in this domain, our system differs primarily as it integrates the environmental setup for growing different varieties of crops. A single controller enabled system managing growth of multiple of crops which if manually handled will pose a number of difficulties.

III. PROPOSED WORK

A. Overview

The growth environment differs for each and every crop based on the morphological and genetic structure. The proposed work deals with integrating the growing environment for individual crops on to a single system. This system is designed and built upon for growing three different types of crops which can be further extended to many a number of crops. 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 used 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 requirement and then all of which are integrated. This integrated system will improvise the growth of crops rapidly.

B. Architecture Diagram

The soul of this system is the controller which enables the entire functioning. Arduino UNO 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. All the water and nutrient solution are placed in a reservoir from which they are sent to the crops. The proposed hydroponic system module is described in Fig 1.

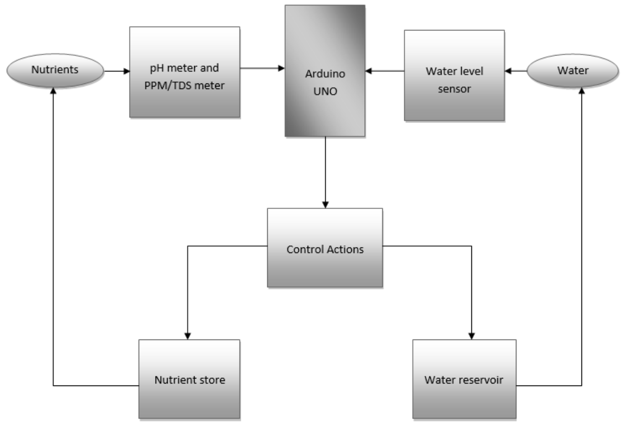

Fig. 1. Hydroponic system module

The system comprises of L293d motor driver which acts as a valve for controlling the nutrient and water supply, mentioned in Fig 2. In addition, it has a mixing tank to dilute the nutrient solution with water and this solution is fed to the crops. There are sensors being placed in the mixing tank to constantly monitor the values, and feed the results to the controller. The controller operates the motors based on the pH values of the nutrient solution and the level of the mixture. This helps in the proper functioning of the system.

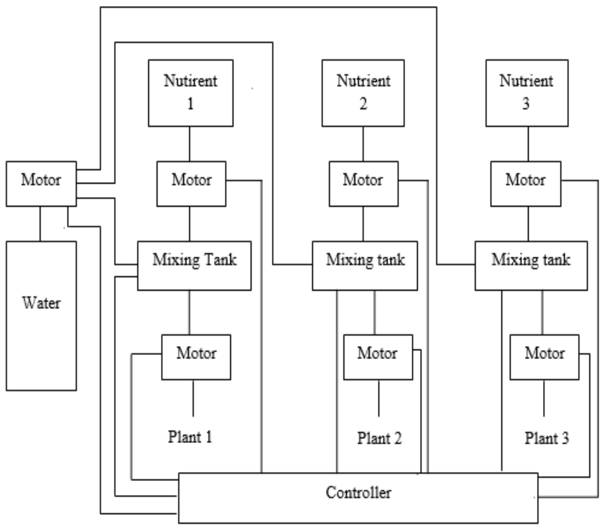

Fig. 2. Control oriented architecture

C. Proposed Modules

A. System Framework

The system is formulated by initially building up a setup for a well-organized flow and functioning. This is essential as there are a 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. The setup as in Fig. 4, is built upon by using PVC pipes, which is needed as a carrier for flow of water through it. Inside this, net pots are placed for holding the plants upright and facilitating their growth. These net pots contain clay balls that are porous and specialized to stimulate and set the right environment for plants as shown in Fig 3. The tiny pores enable holding of water by these balls. Water and nutrient supply needed for the crops are made available in a reservoir. Motors for the control and regulation of water and nutrient supply are fixed in the setup. This setup enables a systematic functioning of the hydroponic system which are necessary. The next step would be to lay ahead with the control part as in Fig. 5. Arduino UNO processor is used for the overall control of the system. Necessary programming is done and the processor is made to perform the required functionalities. It drives the motors and controls the water and nutrient flow. Other components used are L293d motor driver, pH sensor and water level sensing electrodes. And necessary IC's are used for operating the system. These components are generally needed for growth of individual crops too but a set up being integrated to include multiple such crops is done.

Fig. 3. Plant saplings used for growth

Fig 4. Initial setup

Fig 5. Arduino Controller

B. Calibration of Metrices

A constant monitoring and a check on the water level and the nutrient solution used for the crop growth should be done. Calibrating their measurements as required based on the plant's need is essential. The pH value of the nutrient solution used for each crop is studied under various conditions. This value will be used as a threshold for determining the nutrient solution requirement. The Arduino UNO processor is programmed with these pH values and once the pH value changes from the required one, the processor will enable the motor driver. This motor driver will regulate the nutrient supply until the desired pH value is obtained. A similar approach is adopted for the checking of water level. The water level sensing electrodes are used for calibrating the quantity of water needed for every crop. Any discrepancies in these values will be fed as an input to the processor and the programmed processor will either enable or disable the motors accordingly.

TABLE I. pH VALUE FOR CALIBRATION

S.NO.	CROPS	pH VALUE
1.	Mint	6 to 6.8
2.	Tulsi	6 to 7.5
3.	Diffenbachia	5 to 6

Based on the above pH values and water levels crops are fed with the necessary nutrients and water. For instance, the pH value needed for the Mint plant is around 6 to 6.8 and this value is programmed into the Arduino processor. The pH sensor constantly monitors the pH of the nutrient solution flowing to the crops and once the value drops down the threshold, the controller will get the input. Further, it enables the motor driver to supply the nutrients from the nutrient reservoir for the crops till it reaches the appropriate pH value. After the desired pH value for this crop has been achieved, the processor disables the motor driver and stops the nutrient supply. This process repeats continuously till the yield is obtained. The pH of a crop solution may decrease due to abundant supply of water to it when the water level of the solution reduces as plants take in this solution for growth. As and when water is fed the pH content varies due to which pH is fed into it. The richness in the plants growth is maintained by the accuracy in functioning of this system.

c) Programming the Controller

The working of the controller needs to be efficiently formulated. For this an effective algorithm has been proposed for coding the Arduino UNO processor as shown in Fig 6. The algorithm is devised in such a way that the entire hydroponic system works optimally without any flaws. Input to the algorithm is got from the values obtained from the pH sensor and the water level sensor. A threshold has been set for these values in the algorithm and if the condition is met appropriate functions are performed. The algorithm deals with effectively and rapidly enabling the motor drivers once the values obtained from the sensors are fed into the processor. Here the most important aspect is enabling and disabling the motor drivers within fraction of seconds. The proposed algorithm satisfies this condition and aids in regulating the smooth functioning of the system.

Algorithm: Programming the ARDUINO for regulating the water and nutrient

Input: l (level of water obtained from sensor), p (pH value obtained from sensor)

Output: Control regulation of water and nutrient flow

Process:

l_1 – necessary water level for mint

p_1 – necessary pH value for mint

```
while (l < l1)
Begin filling with water's motor and stop the
mixing tank's motor
if(l>l1)
Stop water's motor
while(p>p1)
Start pH motor and stop the mixing tank's motor
if(p<p1)
Stop pH motor
while(l<l1) && (p<p1)
{
Run mixing tank's motor
delay();
}
```

This routine is followed for all the other crops in the system.

Fig. 6. Water and nutrient regulation algorithm

d) Integration of the Controller and the setup

The setup built for creating a growth environment for the crops is integrated with the controller which has been programmed. The integration is very essential for a systematic flow of control to happen. The main part of this integration is combining the growth of multiple crops under a single system. It is essential for the yield of crops to maximize. Another advantage of such integration is automation of system enables reduction in manual workforce. Facilitating the effective integration of wide variety of crops reduces time consumption. It is very simple to get complete control over nutrient balance. Hence a continuous monitoring of the nutrient concentration in the circulating water is done to maintain the level of organic substances that we supply.

IV. PERFORMANCE ANALYSIS

The below chart illustrates on the time a crop takes to be grown under different environmental conditions. Traditional method follows the conventional way of growing crops using soil. The existing approach grows individual crops in hydroponic environment whereas the proposed work deals with an integrated hydroponic environment enabling growth of multiple crops.

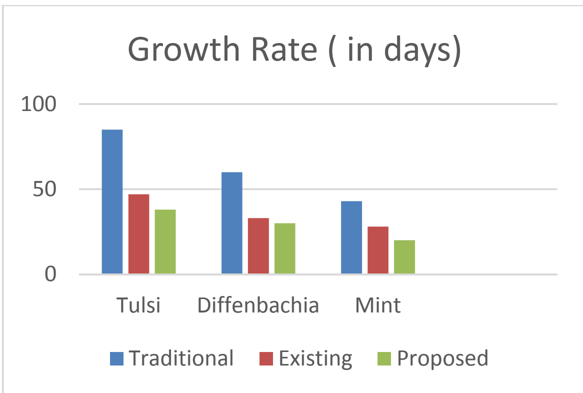

Fig. 7. Growth rate of crops

The results of the chart as in Fig. 7, gives a clear picture on which method is advantageous and provides quicker yields. The proposed system allows plants to be grown at a mightier pace and the yields are provided at efficient and affordable costs. The next chart in Fig. 8, explains about how cost parameter affects the hydroponic system.

The cost of construction of an existing hydroponic system for growing individual crops separately is around Rs.13,000 as quoted in Fig. 6 The proposed system due to its necessity to integrate, compensates on cost factor charging Rs.15,000. Though the expenses are more on initial setup it overcomes the expenditure by reducing cost per growth of crops.

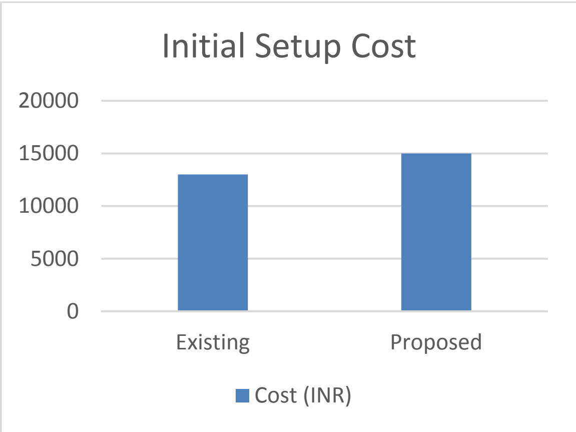

Fig. 8. Initial cost for setup

Fig. 9 illustrates the cost per crop in existing as well as the proposed system. Since the existing system deals with individual crops, the cost is quite high. But, the proposed system integrates multiple crops which considerably reduces the cost.

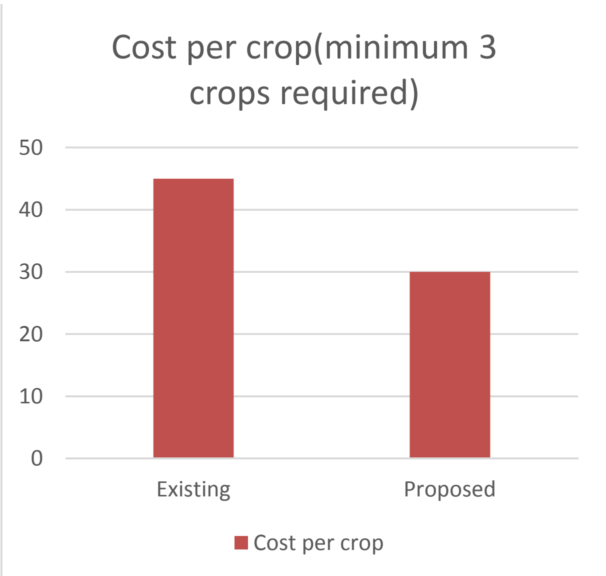

Fig. 9. Cost per crop

These statistical correlations between the traditional, existing and the proposed system emphasizes that the proposed system out numbers the others. This comparison made by using the cost and growth as factors makes it evident.

V. CONCLUSION

The proposed hydroponic system hence implements the integration of different varieties of crops. The short comings of the existing system like growth of a single type of crop in the entire system have been overcome. A methodological approach has been taken forth to regulate the working of the system. The plants grown under this system is analyzed with traditionally grown ones and has been found that these plants grow a lot quicker with minimum requirement of nutrients. They are much cleaner with minimum chemical constituents using up only required water, preventing loss of water. Also the cost for cropping is nominal on consideration of its advantages. Hence this model encourages practicing of an alternate approach towards farming that is eco-friendlier and efficient on comparison with upcoming techniques.

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