An AI Based System Design to Develop and Monitor a Hydroponic Farm

Hydroponic Farming for Smart City

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Abstract— Soil Erosion leads to decrease in agricultural production leading to desertification. Also Factors like Overuse of Fertilizer which increases the salinity of the soil; Global warming and natural calamities which is creating an issue on the climate change; and Bio-tech Industries which are creating hybrid seeds with customized fertilizer eliminates the fixation of nitrogen cycle crops which in turn has an adverse effect on the soil and humans consuming it. These entire problems eventually leave a farmer with less fertile land to cultivate the crops. Solution to these problems is to start with a Hydroponic Farming where crops are grown without soil, into a closed or open environment depending on the size and width of the total crop length. Plants grown hydroponically are generally healthier than their soil-grown counter-parts, because they receive an almost perfectly balanced diet and rarely come in contact with soil-borne pests and diseases. Since hydroponic systems reduce water and nutrient stress to the plants, they grow faster and can be grown closer together without starving each other. Healthier plants also produce higher harvests. In this paper, we proposed to prepare an Artificial Intelligent system to do hydroponic farming in closed environment which will automatically deliver mix of water and nutrient solution along with light, directly to the roots of plants using sensors. For experiment we are using Tomato F1 Hybrid Suhyana seed. This system will help in calculating the average growth rate ratio for Tomato F1 Hybrid Suhyana seed that are grown hydroponically and would compare it with soil grown plants. This system will not only benefit the local farmers whose land has been degraded but will also conserve water by stopping evaporation and runoff, Losses due to drought and flooding will be significantly reduced.

Keywords—hydroponic farming; Tomato F1 Hybrid Suhyana seeds; Italian Tomato Hybrid seeds; K Nearest Neighbor

I. Introduction

Growing of plants in water replacing Soil is known as hydroponic plantation. It helps to evade unwanted accumulations of undesirable absorptions of nutrients present in the soil. In this type of plantation plants don't use soil to grow instead they use the nutrient present in that soil. These nutrients are mixed with water and supplied to plant to anchor their roots. As the food is dissolved in water, it goes directly to their roots which eventually lead to grow faster growth and higher yield of plants. Problems like soil-borne diseases, pests or weeding can be avoided by adopting this method of Soil less farming. This type of plantation can grow more plants in the same space as compared to a soil garden. This is a more efficient way to supply food and water to your plants without use of soil. Using Hydroponics planting issues like nutrient deficiency and impact of natural Calamities can be easily avoided. Also use of herbicides, fungicides, and pesticides, won't be needed as we are opting for soil less planting in a closed environment, which will result in healthier plant production. Also agricultural workers are not exposed to toxic chemicals, and labor costs are reduced. Even regions with water scarcity or non-arable land problems, can cultivate good crops. Perfect plant conditions results in perfect plant production.

II. Literature Review

Current Study on hydroponics farming is fairly at a great rise and there is lot of scope for improvements. The intention of our survey was to find different means through which hydroponic system can be implemented. We also investigate the possible technology, important parameters and a suitable design for proper functionality of our hydroponic system. Many researchers have come to a conclusion through their research that plants are able to absorb and consume supplied nutrients in plain water and found that soil wasn't even a necessary component for plant to grow.

Projects were taken up by OpenAG and MIT, to develop an internet assisted farming system for controlling the hydroponic farming in a closed environment. This system was supervised by humans. Their main aim was to focus on flavour of their crop and not on the yield percent of the crop[1]. In a paper [2] , they have decribed the process of how to control the nutrient solution of tomatoes. Which deals with certain species of tomato crops and their nutrient index in hydroponics farming. No such system is available which will commercialise and yield higher growth for the huge population. Some first advances were seen in this field where cherry tomato culture was successfully grown[5].This paper describes the development of Hydroponic a system for Cherry Tomato. Through electrical conductivity nutritious hydroponic solution were provided. This became the monitoring parameter for the system. In Paper[3], researchers have come up with a system which shows how automatically a hydroponic system can be implemented using electronic circuit. Paper [4] presents an idea about how to supply nutrient solution using electronic system. Research papers have given basic idea to develop automated System for Hydroponics. In paper [6] researchers have described the development of an automated Hydroponic system using Microcontroller. In this research paper micro controller and sensor is use to control System for Deep Water Culture System. Paper [7] describes how automatically amount of water, fertilizers and climatic conditions would be adapted by the system for providing nutrient solution for hydroponic farming. Various sensors were used to gather the data from the system. All the systems are fairly great in their own sense and is being developed to focus on certain parameter, but no systems targets on higher yields of crop using artificial intelligence as a tool to monitor the growth of a particular crop. Following table shows a comaprative study of all the literature survey we have carried.

TABLE I. COMPARATIVE STUDY OF EXISTING SYSTEMS

Sr.no	System	Method	Goal
1	System in article [1]	Using Closed Environment.	Focusing on how to improve flavour of particular crop.
2	System decribed in Paper[2]	Using Open Air Environment controlled automatically to monitor plant growth.	To provide mix of nutrient solution and water , automatically to plants.
3	System decribed in Paper[3]	2 Electrode sensor for measuring water conductivity of hydroponic system is presented	Measuring conductivity of Nutrient solution.
4	System decribed in Paper[4]	Automatically supply of Nutrient solution using electronic system	Balancing the Nutrient Index in a tomato crop.
5	System decribed in Paper[5]	Developed Hydroponic System for cherry tomato through electrical conductivity.	Focused on higher and better yields of cherry tomato.
6	System decribed in Paper[6]	Developed Hydroponic system using microcontroller and sensor.	Control System for deep water culture system
7	System decribed in Paper[7]	Developed Nutrient Solution Mixing Process using Time-Based Drip Fertigation System	Automatically Controlling amount of water, Fertilizer and climatic condition

Various organizations have developed the systems gathering different amounts of data for tomato crop or its different species based on parameters like sunlight, Soil, Water, Temperature and fertilizer. Out of theses following parameters we would be using only Water, Light, and supply Nutrient of Soil directly into water. Also Environment Temperature is taken into consideration.

TABLE II. DIFFERENT PARAMETERS USED FOR PLANT GROWTH

Sunlight	Soil	Water	Light	Fertilizer
Solarize your soil to control nematodes, weeds and other pests and disease pathogens. Moisten the area and cover it with a sturdy plastic trap.	Choose well drained, deep and loamy soil. Organically enriched soil with a pH between 6.2 and 6.8 is best for flavor. Blos som-end rot is due to calcium deficiency. Lime the tomato soil at the rate of 5 pounds per 100 square feet.	Tomato plants need at least an inch of water per week; so water them well, especially during dry spells.	Germin ation 60-85 F For Growth 70-75 F	Fertilizer 1 week before planting. Avoid high N and K at blossom time. Too much leaf growth may indicate too much N or too much water Fertilizer formulas such as 5-10-10 are good. Bone meal or ground rock phosphates are also good.

Data given below in table III is of the hybrid Suhyana seed, which is directly being taken from nursery live.com website.

TABLE III. CHARACTERISTICS OF TOMATO F1 HYBRID SUHYANA SEEDS

Name	Flower colors	Bloom time	Height	Difficulty
Tomato Botanical name: Solanum lycopersi cum	Yellow	Year round	Height : determinate 3-4 , indetermina te 7-15 Width 24-36"	Moderately difficult

In traditional farming, Tomato F1 Hybrid Suhyana requires watering consistently in first few days and during summer season about 2 inches per week. It needs to be fertilized two weeks prior to first picking and again two weeks after first picking. For harvesting, Tomatoes require from 50 to more than 90 warm days to reach harvest depending upon variety. For this we need to leave the tomatoes on the vine as long as possible. The perfect tomato for picking will be firm and very red in color, regardless of size, with perhaps some yellow remaining around the stem.

III. PROPOSED SYSTEM

The proposed system is to build a hydroponic farm in a closed environment which will be automated and with the help of sensors attached to the system it will use proper amount of nutrients and water composition for a particular temperature to grow Tomato F1 Hybrid Suhyana seeds. Lights supply plants with energy, which is used in the photosynthesis process to make foods. So light sensors are used for maintaining the light intensity inside the hydroponic box, which is another essential factor for growth of a plant. This system is designed especially to guide farmers for producing healthier plants with higher yields.

We initially plan to grow Tomato F1 Hybrid Suhyana seed for the initial yield test in presence of human observation to collect data. This would help us to automate the system completely where AI system will not only automatically supply amount of nutrient, light and water content required to grow Tomato F1 Hybrid Suhyana seed but also monitor and compare the growth of each hydroponically grown plants. This comparison will further be used to calculate the average growth rate of this plant. This system if done on large extent will give enormous amount of data on different crops, for Soil less farming. And will be of great beneficiary for the study in agriculture. Plants in Hydroponic farm will grow 25-30% faster than traditionally grown plants and will provide plants with extra oxygen in the growth phase.

IV. SYSTEM IMPLEMENTATION

A. *Construction of the System*

For building our system we need to first grow small saplings into minute amount of soil. Then these saplings are transferred to the grow box which contains small holders to hold the plants with their roots submerged in the water. Through sensors we will control light, water and pH level provided to the system at every instant. Here light sensor will be placed at certain length from Led grow lights which will eventually help in growing of plant. Water Sensors will be placed in the bottom part of the box where the water holding space is there. Also pH sensor will placed in the water to measure the water acidity level. Following "*Fig.1*" shows the architectural Diagram of Our hydroponic system:

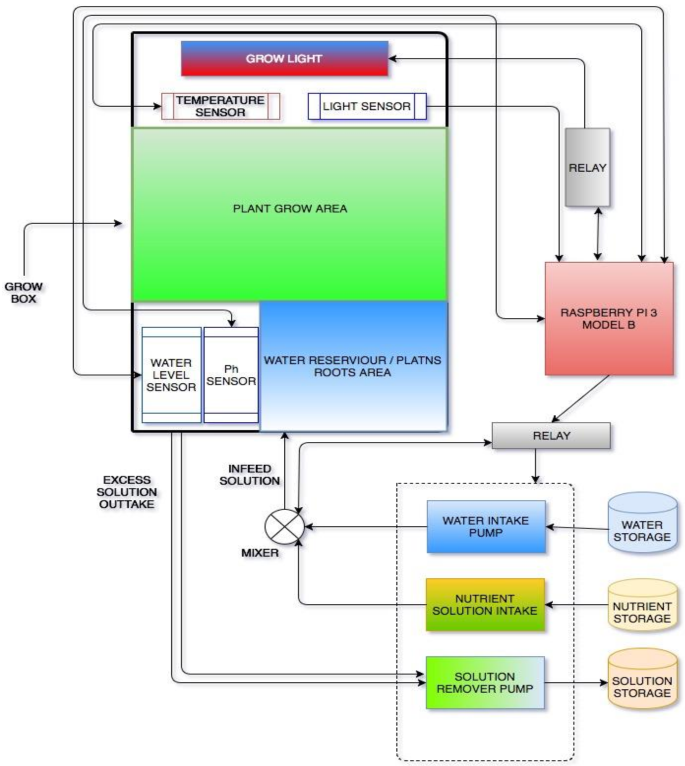

Fig.1: Architectural Diagram of Hydroponic system

Assembling the hardware is necessary for the growth space of the crop. Following are the steps involved in setting up the system and its use to do so:

Step 1: Non-Electrical hardware & Its Uses.

a) Creating a box which can hold a certain amount of water, a growth mesh small pots for holding the plants in the box with roots submerged in water and upper body of the plant.
b) The box is a closed box which contains (2W LED Plant Grow Light) also two 120 mm fans for maintaining the air flow and regulating the positive air pressures in the box.
c) Also the lower part of the box will contain the pH electrode & water level sensor for maintaining the water level so that roots don't get submerged in the water for a long period of time as they can rot overtime. PH electrode to read the values of the acidity of water and nutrient solutions.

Step 2: Assembling Electrical hardware and Its Uses.

a) Raspberry Pi 3 with Micro controller to control all the sensors connected to it.
b) Temperature sensor will measure the temperature and if the temperature is high inside the box then, it will switch off the lights, else it will be idle. The standard temperatures will be about 25 to 40 degree Celsius. If the temperature exceeds above maximum range then the lights will be switched off else, if below minimum range then light intensity will be increased.
c) Plant Grow Light Red and blue color to give necessary light intensity for the plant to carry on photosynthesis.
d) Light intensity usually generates heat in the grow box, so it's essential for us to control it. Light intensity sensor will measure the light luminescence levels of the grow light, here we ensure that it mimic the natural daylight intensity. Based on the day time and night time light, we are programming the system in the following manner:
    i. From 6 am to 10 am we will keep light intensity low, if temperature below the 25 degree Celsius, override the LDR and increase the light intensity.
    ii. From 10 am to 3 pm we will keep light intensity high, if temperature exceeds above 40 degree Celsius, override the LDR and decrease the light intensity.
    iii. From 3 pm to 7 pm we will keep light intensity low, if temperature increases or decreases in the grow box adjust the temperature by maintaining the light intensity.
e) Water level sensor will maintain the water level with high, mid and low level, of water in the reservoir. The level of water is defined in the system in the following way:
    i. High = maximum 2 litre water will be in the reservoir.
    ii. Normal = approximately near about 1 litre of water in the reservoir.
    iii. Low = less than 400 ml of the water in the reservoir.
    Water sensor works with three contact points that are attached to the walls of reservoir, we know the actual capacity and length of the reservoir, and by placing the water sensors to three distinct places we can estimate the values of the water in litres. For example, 2litre is maximum capacity of reservoir, and reservoir length is 30cms. Then 1litre will approximate to about

15cms and 400ml will approximate to about 7.5cms, so we place the three sensors on 30 cm, 15 cm and 7.5 cm respectively. And these sensors will tell the system whether to start the water pump or not. Ideally we are going to maintain 1litre water in the tank.

f) PH Sensor is used to sense the acidity level of water solution which is mixed with nutrient solution. Normally the ph values range from 0 to 14 where 0 being acidic solution and 14 means alkaline solution. In our system we are maintaining a pH value in the range of 5-7pH. So if the Ph sensor senses High level of water acidity that is more than 7pH, it will command the raspberry pi to drain the solution from the reservoir else it will be idle.

B. Methodology of the System

The AI based hydroponic system is used for monitoring the growth of a plant and collects environmental information such as Temperature, Light, water level, pH level, Nutrient supply which are essential factors for the growth of crops. So the prerequisite for the system to work is to assemble the entire system and check whether all sensors used in the system are fully functional or not. In the initial phase, our system will gather the data using sensor capturing different phase of tomato plant growth which will take around maximum of 15 to 20 days to grow its small fruit bud. We would be using Deep Flow Circulating System to maintain the nutrients flowing in root channel of the crop. In this process, we will follow the following set of rules to work on:

1. Plants are placed in a net pot in the grow box and are held by a floating platform above a water reservoir containing a mix of nutrient and water.
2. Plant roots are suspended and stretched into the nutrient rich solution at a minimum distance of 3-4 cm from the roots of the crop so that it should just touch the water. If submerged they will rot.
3. Keep light intensity low at start of the day during 5:00am in the morning, increasing during the course of hours incrementing the light intensity to about moderate at 6am to 10am, and high during 10am to 3pm. then decreasing gradually till 7 pm, after that shutdown the lights. This will mimic the day sunlight pattern and will allow the plant to grow in its natural state.
4. Gather the data collected from the sensors and maintain the table for the entire growth and development phase of a plant.

The value of parameter includes:

i. Temperature Levels [Cold, Warm, Hot]
ii. Water Levels [Low, Normal, High]
iii. pH levels i.e. levels of acidity [Acid, Neutral, Alkaline]
iv. Light Intensity Levels [Low, Normal, High]

Domain values of these variables consisted of:

i. Temperature Level variable
    a. Cold [15-24 degrees].
    b. Warm [25-30 degrees].
    c. Hot [31-40 degrees].
ii. Water Level Variable
    a. Low [400 ml]
    b. Normal [1000 ml]
    c. High [2000 ml]
iii. pH level Variable
    a. Acid: [less than 5pH].
    b. Neutral: [5-7pH].
    c. Alkaline: [more than 7pH].
iv. Light Intensity Level Variable
    a. Low [1000 lm]
    b. Normal [1200 lm]
    c. High [4500 lm]

Based on the rules set during construction the value of variable proper [Yes, No] would be decided. Following are the rules set:

i. If time= 6 a.m. - 10 a.m. & Light=Low & Temp=cold then this is not proper growth condition for plant so we Increase Light.
ii. If time= 10 a.m. - 03 p.m. & Light=High & Temp=Hot then this is not proper growth condition for plant so we Reduce Light.
iii. If time= 03 p.m. - 07 p.m. & Light=Low & Temp=Hot or Cold then then this is not proper growth condition for plant so we Reduce Light if temp=hot else maintain the light=Low.

TABLE IV. DATA COLLECTED IN THE TRAINING PHASE OF THE SYSTEM

Day	Time	Temp	Water Level	pH level	Light	Proper
D-1	6 a.m- 10 a.m	Warm	High	Neutral	Normal	Yes
D-1	10 p.m- 3p.m	Hot	Normal	alkaline	High	No
D-1	3 p.m- 7 p.m	Warm	Normal	Neutral	Normal	Yes
D-2	6 a.m- 10 a.m	Cold	High	Neutral	Low	No
D-2	10 p.m- 3p.m	Hot	Normal	Neutral	High	No
D-2	3 p.m- 7 p.m	Warm	Normal	Neutral	Normal	Yes

Once the data is collected in the manner given in table IV for one plant, we will be able to compare growth of traditional grown plants and hydroponic grown plants. In order to achieve this we can maintain a separate table wherein we can collect width and height of plant throughout its growth phase. This model will eventually help us to identify growth rate with which plant in hydroponic system will grow and also percentage of plants that will die in this process as compared to naturally grown plants. In order to estimate the efficiency of proposed model we will be checking whether all plants grown in hydroponic system using same parameter values resulted in same growth rate. We will be planting 2-3 plants for same breed of tomato crop in hydroponic farming. By collecting data for the same, we can actually compare growth rate of each plant and come up with average plant growth rate for this crop using our system.

V. CONCLUSION

This paper shows how automatic hydroponic system can be implemented using Raspberry Pi 3 with Micro controller to control and monitor all the sensors connected to it. This system is implemented in closed environment for automating crop plantation. It describes how the mix of water, Light and nutrient solution will be automatically delivered to the roots of tomato plants by maintaining the pH level of the nutrient solution and temperature. This is a novel approach which would help us to collect data and construct model for Tomato F1 Hybrid Suhyana crop. This model will be able to give the average growth rate ratio of Tomato F1 Hybrid Suhyana crop that are grown hydroponically. Also it would be helpful in comparing growth of natural grown plants and hydroponically grown plants. In this entire process system will use less water and fertilizer as compared to soil farming. Also this system promises to give better and faster yields as compared to soil farming.

VI. FUTURE SCOPE

The same system can be further scale into stack farming where special warehouse or commercial buildings can be constructed to grow plants which would eventually lead to Smart City Farms. Like Tomato F1 Hybrid Suhyana crop we can grow other crops under hydroponic farming. This would help us to identify plants that are more suitable and having favorable growth rate under hydroponic farming.

ACKNOWLEDGMENT

I would like to acknowledge my guide Prof. Safa Hamdare and all my other Professors for the timely guidance they provided to bring this idea become a reality.

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