Impact Factor (SJIF): 5.301

International Journal of Advance Research in Engineering, Science & Technology

e-ISSN: 2393-9877, p-ISSN: 2394-2444

Volume 7, Issue 5, May-2020

Hydroponics: A Review Soil-less Culture

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Abstract — ***Agriculture has always has been a practice done in open or soil based field. But with increasing population, decrease in per capital land availability, this practice is facing challenges more than before. With ever growing urbanization and industrialization, as well as increasing sea level and iceberg melting, available land is decreasing at much more rapid rate. Along with this use of chemical fertilizers, poor water management, rid lands, decrease in water table, polluted water bodies and many more such activities it is creating problems which we have never faced before. With such developments, it will be hard and impossible for us to feed entire population in future with present agricultural practices. Even more problems arise, when plants get infected by various diseases due to climate changes, pests, and chemicals in soil.***

Under such undesirable conditions, possible solution for this unseen problem is Hydroponic culture or also known as soil less farming. The whole system involves using of water and soluble minerals mixture to grow plants, in our case agricultural products. It is possible to improve space as well as available resources to perform Hydroponic farming at the same time with promising results all over the world.

This paper describes design and development of system using raspberry Pi for image processing to recognize plant diseases and a soil less farming process to increase the productivity of farms.

Keywords – Hydroponic, Raspberry Pi, Agricultural, IoT, Image Processing

I. INTRODUCTION

Open field agricultural is feasible when available resources surpass the needs of present population in the region. In past, this was true, but today, scenario is different. Soil is most preferred medium used to grow plants and crops. With all nutrients, water, anchorage, soil is best medium. But in many cases it has also shown limitations like microbes, pests, unfavorable soil composition, poor water holding capacity, and many more. But main problem with tradition practice is huge requirement of space or open field, labor manual or not, and large volume of water. This becomes even more hard when metropolitan cities come in picture. Even if land is available, scarcity of fertile soil and various unfavorable geographical conditions, open field farming is not possible. Under such tight conditions, soil less culture is most suitable option, and can also be introduced without any hindrance. This system also helps us to face recent climate changes and also proves to be efficient way to manage production as well as natural resources available with us.

Soil less culture refers to system or techniques of hydroponic. It is a method which uses mineral and nutrient solution, to grow plants. In hydroponic technique, roots of plants immersed in a nutrient solution.

W. J. Shalto Douglas in year 1946 introduced hydroponics in India. He also established a laboratory in Kalimpong area, in West Bengal. He published a book on called “Hydroponics the Bengal System”. Many automated hydroponics farms and systems were established around the world by the end of 1980’s.

II. Literature Survey

2.1 Technique Available for Hydroponic Culture

There are six main or basic techniques of hydroponic system. There are various variations present on these six systems. All available system has a reservoir or tank of nutrient solution, with precautions taken to prevent algae growth.

- **Wick System**

It is passive and simplest hydroponic system of all present systems. No moving parts are involved in this system. Here, nutrient solution is provided to plants from reservoir with the help of a wick. This system can be used with wide variety of growing mediums like perlite, coconut fiber, mineral wool to name few. A separate air pump is required to keep water and nutrient solution oxygenated. The only drawback for this system is that plants may use or require solution faster that wick can supply. Plants may also use up the water more quickly than wick may supply.

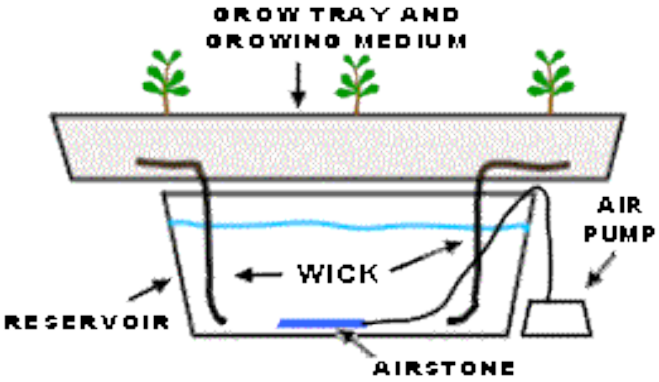

Fig – Wick System Source: **https://www.simplyhydro.com/system/**

- **Water Culture**

The water culture is a simplest active system. A platform is made which will hold the plants and floats directly upon nutrient solution. Air pump is used to supply required oxygen to solution and through it to the roots of plants. Water culture is best choice to grow leafy plants. Very few plants than leafy will perform better in this system. The drawback for this system is that it does not work well with large or long term plants.

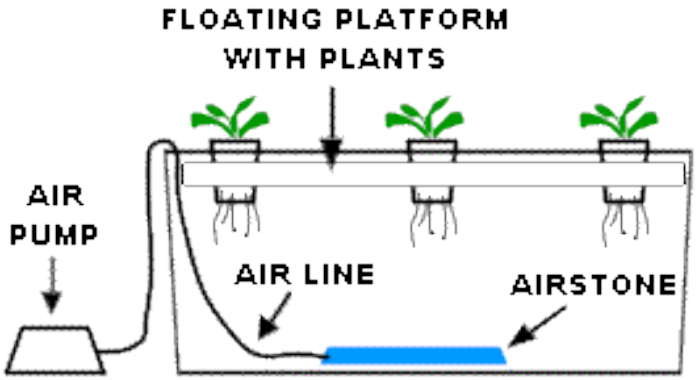

Fig – Water Culture System Source: https://www.simplyhydro.com/system/

- **EBB and Flow – (Flood and Drain)**

The Ebb and Flow system works by momentarily flooding the tray in which plants are kept with nutrient solution and the later on draining excess solution back into reservoir. The Ebb & Flow is a versatile system which can be used with wide variety of growing mediums. The main disadvantage for this system is that roots can dry out if the water cycles are interrupted. The system is also quite vulnerable for power outage as well as pump and timer failures as they are responsible for timely flooding of the try wit nutrient solution for plants.

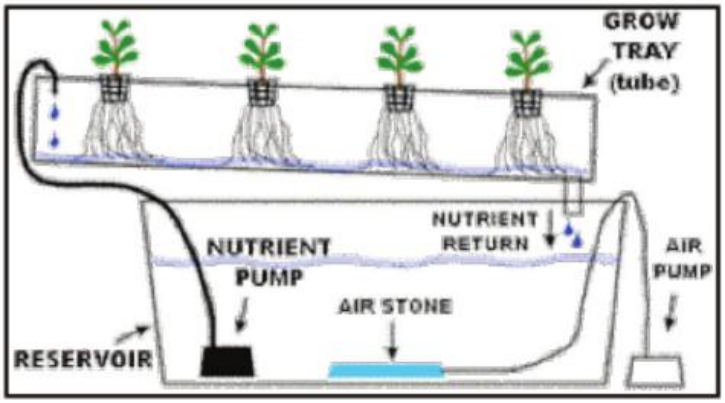

Fig – EBB and Flow System Source: https://www.simplyhydro.com/system/

- **Drip Systems Recovery/Non-Recovery**

Drip Systems is probably most widely used system around the globe. In operation, a timer along with submerged pump is used. The timer turns the pump on and nutrient solution is sent to plants roots with the help of drip lines in drops. Recollection of nutrient solution back in reservoir is main difference in recovery and non-recovery drip system. In recovery system, the nutrient solution is used more efficiently as the excess solution is reused. System also does not requires a precise water controlling cycles, while in non-recovering systems precise water control is required. Periodic nutrient solution maintenance is required in recovery system as pH and nutrient strength may change due to constant solution movement.

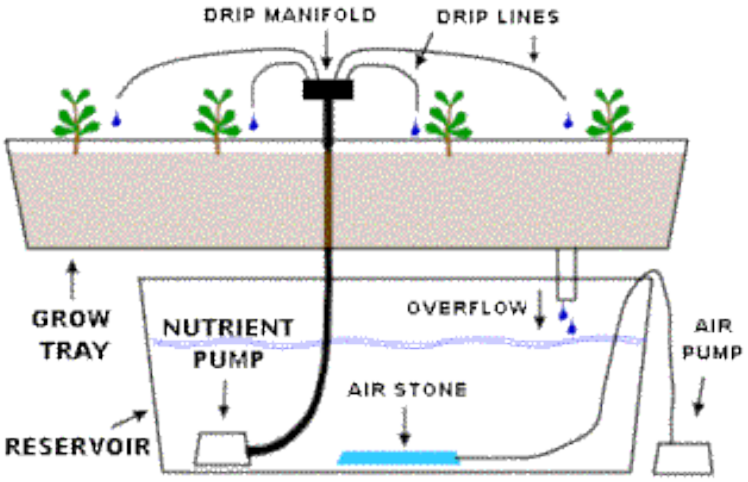

Fig – Drip System Source: https://www.simplyhydro.com/system/

- **Nutrient Film Technique (N.F.T)**

N.F.T. systems have a constant flow of nutrient solution so no timer is required for the submersed pump. The nutrient solution is pumped into growing tray and then it flows over the roots of the plants, and excess drains back into the reservoir. Other that air no other growing medium is used, which saves the expense. The plants are supported in a small plastic basket with the roots dangling into the nutrient solution. Drawback to this system is that they are very susceptible to power outages and pump failures. The roots can also dry out very quickly when the flow of nutrient solution is interrupted.

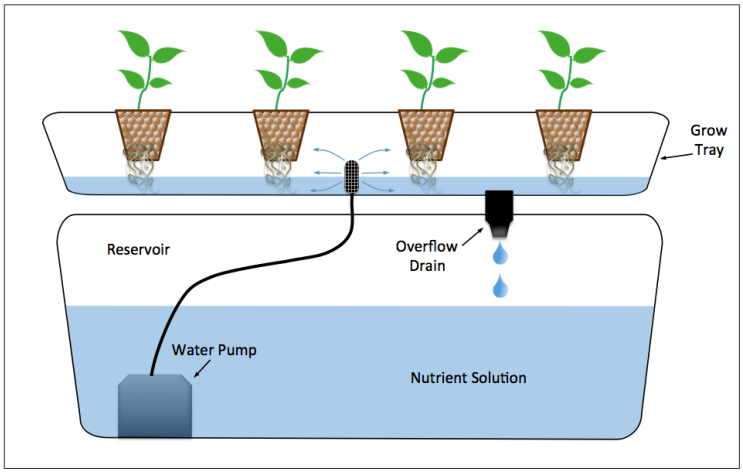

Fig – N.F.T System Source: https://www.simplyhydro.com/system/

- **Aeroponic**

The aeroponic system is the most advanced type of hydroponic gardening system of all six methods. Like the N.F.T. system, the growing medium used is air. The roots hang in air and then are sprayed with nutrient solution. The spraying is usually done in fixed amount of intervals. Because the roots lay bare to the air like the N.F.T. system, the roots will dry out quickly if misting cycles are interrupted. A timer is used to control the nutrient solution pump and this system also needs a short cycle timer that runs the pump for a few seconds to couple of minutes to spray the nutrient solution.

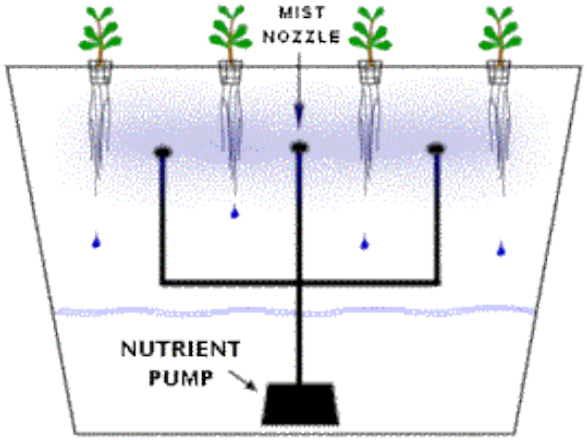

Fig – Aeroponic System Source: https://www.simplyhydro.com/system/

2.2 Digital Image Processing

Some papers are describing to detecting leaf disease using various methods suggesting the various implementation ways as illustrated and discussed here. This paper presents of two phases to identify the affected part with the disease in the plant. Initially Edge detection based Image segmentation is done, and finally image analysis and classification of diseases is performed using Homogeneous Pixel Counting Technique for Cotton Diseases Detection (HPCCDD) Algorithm. The goal of this paper is to identify the disease affected part of leaf by using the image analysis. The computer systems will analyze the given images using the RGB pixel values and identify disease and next step is homogenization techniques. Sobel and Canny edge detection will be used to identify the affected parts of the leaf spot to identify the diseases boundary with white lighting and then result is recognition of the diseases as output. Detection of leaf diseases can be done in three stages:

1. identifying the infected object or parts by using k-means clustering algorithm;
2. using color co-occurrence methodology for texture analysis and to extract feature set of infected objects;
3. detecting and classifying the disease type by using neural networks, and the presented scheme also does segregation of plat leaves in two different classes i.e. infected and not-infected

This paper showcases two techniques for feature extraction and comparison. Otsu Threshold: this creates binary image from gray level by assigning the value zero to pixels below threshold and one to pixels about threshold. K-Means clustering is an unsupervised learning algorithm where identification a finite set of clusters will be done to the data, in our case the images of infected and non-infected leaf images form the plants.

In this paper [1] authors are focused on Rice disease identification and took two diseases in consideration, Leaf Blast & Brown Spot. For feature extraction of infected parts from plant's leaves, Boundary detection & Spot detection methods were employed. Authors also introduced Self Organizing Map (SOM), a neural network zooming algorithm for classification of images containing rice diseases. In SOM padding of zeros is done for making vector input & for interpolation of missing points, with zooming algorithm provides satisfactory result.

In this paper [2] authors have considered five plant diseases from Jordan's Al-Ghor area, namely Late scorch, Cottony mold, Early scorch, Ashen mold and Tiny whiteness for testing purpose. For segmentation of leaf images K-Means clustering method is applied and the Color Co-occurrence Method (CCM) is used for texture analysis of infected leaf. For plant diseases classification, back propagation algorithm in neural network is used.

In this paper [3] authors have used MATLAB & LABVIEW vision for detection of disease in chili plant. In early stages leaf inspection can be done combination of these two software. The images of leafs can be captured with LABVIEW leaf and MATLAB is used for processing those captured images. In feature extraction various methods like Edge detection, Fourier filtering, morphological operations are done in image per-processing and color clustering method is applied for separating chili and non-chili leaves from image set. To show of healthiness of chili plant image recognition and the classification is done.

In this paper [4] authors have introduced technique for detection of leaves disease in apple trees (Malus Domestica). Gray-scale images are obtained from equalization of histogram, with help of co-occurrence matrix method algorithm texture analysis in image segmentation is done and K-means clustering algorithm is used for color analysis. Comparison between individual pixels value and threshold value is done in threshold matching process. To detect infected part of plant, texture & color images are compared with previously obtained images of leaf.

In paper [5] authors have described methodology for detection of Bacterial leaf scorch infection in plant. K-means clustering algorithm is used to separate foreground and background images in image segmentation process. For highlighting leaf area Clustering can be done in segmentation based upon subtracting the clustered leaf images and intensity mapping of those images. K-means is simple yet effective method for detection of infected area in the leafs.

In paper [6] authors have introduced leaf detection for Anthracnose, Citrus canker, Overwatering and Citrus greening Citrus plant. Image preprocessing is done with color space conversion by using YCbCr color system & L*a*b* color space for image enhancement by applying discrete cosine transform. For feature extraction Gray-Level Co-Occurrence Matrix is employed, to view various statistics such as energy, contrast, homogeneity and entropy. For citrus leaf diseases detection SVMRBF and SVMPOLY are used.

In paper [7] authors have presented technique for detection of Black leaf & spot leaf disease in Orchid. Preprocessing is done by equalization of histogram, for image enhancement intensity adjustment and filtering is done. Segmentation is done removing & preserving the small & large object respectively by using threshold process. To recog1nize diseases classification is done by calculation of white pixels in leaf images.

In paper [8] authors have described diseases detection technique for Powdery mildew & Early blight for Tomato leaves. Various image preprocessing techniques such as smoothness, noise removal, resizing, image isolation and background removing is performed. For Feature extraction Gabor wavelet transformation is applied. For disease identification Cauchy Kernel, Laplacian Kernel and Invmult Kernel are used in SVM for output decision.

The management of crops required close inspection especially for management of disease infected crop that can affect the quality and quantity of crop. Image processing is a best technique for agricultural application. Image processing can also be used to detect a pest's attack to the plant. The detection and classification of various plant diseases as well as pest attacks are very important task to increase the productivity of the agricultural as well as plant based industries.

Plant disease detection is new and emerging technology in India as agriculture is important sector in Economy and Social life. All data related to farm like sensor data is uploaded to cloud thing speak so that in future farmer or any user can analyze previous data and make required modification for better productivity.

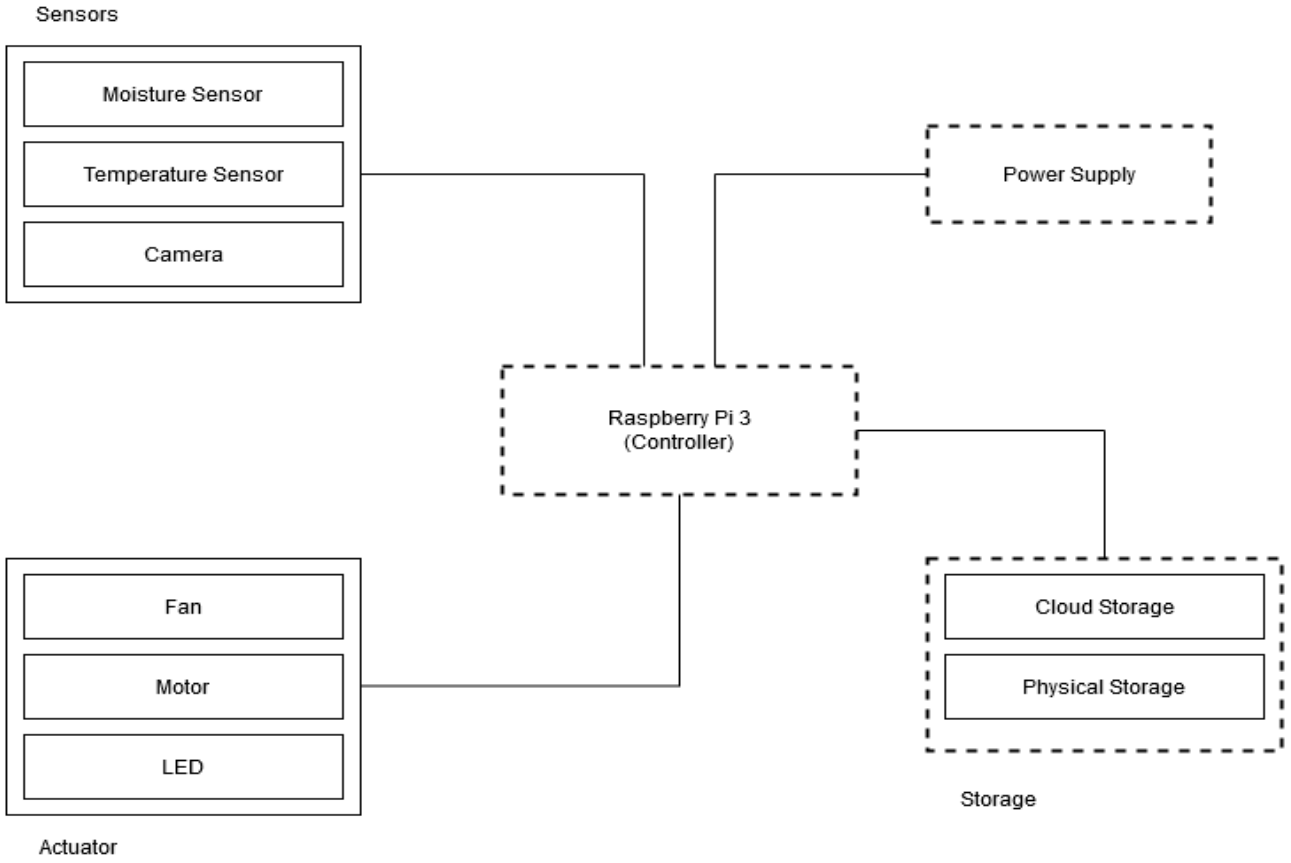

Fig – System Architecture

III. Block Diagram

Sensors – Sensors will interact with environment. Moisture sensor will require measuring the level of water and nutrient solution in the tube and reservoir. Temperature Sensor is used to monitor plant temperature as well as ambient temperature such as room temperature if the setup is in closed place. Camera will be responsible for capturing of images and feeding it to storage devices and from there controller or main processing unit for image processing.

Actuator – Fan is responsible for circulating nutrient solution to the plants, controlled by raspberry Pi. LED is used for various indication purposes. Motor will be controlling the speed of rotation for fan, which in turn affects the flow of nutrient solution in the pipes and reservoir.

Controller – It is responsible for the working of all actuators, and accepting inputs from the sensors. The controller will also act as main hub for processing the images, generating required outputs, storing it at appropriate storage devices.

Storage – Here the generated images as well as processed images will be stored. Physical storage will hold information or data of few days to weeks. Periodically the data will be uploaded or stored on cloud storage.

Power Supply – Depending upon the need power supply can be selected. Battery or mains power supply can be used as per scale of the setup.

IV. Conclusion

The detection of plant disease is one of the important tasks in terms any agricultural related task. A plant disease reduces the production as well as the overall quality of the products. Every year the loss due to various diseases is challenging part in Agriculture production. Although work is carried out till time on detection of diseases but proper segmentation of affected part based on type of plant family is still an open problem in a research area. Farmer can analyze data related to farm using smart cloud thing speak to use this data and implement new farming methodology for improving the production and maximizing the yields for given area or space.

V. Future Scope

In coming times, the demand for food product will increase exponentially with increase of population. With such increased demands, newer methods, increased use of technology is necessary in agricultural area. With improvements in the field of robotics, they can be used to deliver the pesticide, used to monitor the plant conditions, as well decrease the amount of manual workload on the person. A lot work can be done in this regard. Involvement of Artificial Intelligence, Machine Learning and various other computational processes, the yield per capital can be increases and improved.

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