International Journal of Advances in Engineering and Management (IJAEM)
Volume 2, Issue 9, pp: 633-639 www.ijaem.net ISSN: 2395-5252

Smart Farming Using IoT in HydroponicTechniques - Without Using Soil

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Date of Submission: 15-11-2020 Date of Acceptance: 30-11-2020

ABSTRACT: Agriculture is a basic requirement of any nation but due to increase in industrialization, there is decrease in farmland. The traditional method undergoes several problems such as impoverished soil fertility, pesticides, weather and climatic change, humidity level etc. Nowadays interesting techniques are available in agriculture sector. Hydroponics is an improvised platform of agriculture where the crops can be grown with the most abundant compound water having nutrient solution. Many studies portrayed that crops grown with this technique are of high quality. It helps to increase the yield of crop in short duration for any climatic conditions. The purpose of this research studies is to bring automation in hydroponic farming to gain high productivity with the help of Internet of Things (IoT).

KEYWORDS: Smart Farming, Hydroponics, IoT, Healthy crops, Survey analysis

I. INTRODUCTION

According to the Food and AgricultureOrganization of the UnitedNations, to feed the Earth's growingpopulation, the world will need to produce70% more food in 2050 than it did in 2006 [13].The production in agricultural sector is seasonal and the climate is the main cause. There are many other factors that decrease the productivity such as unavailability of cultivated land,lack of finances, change in rain patterns, increase in temperature etc. To increase the production or to achieve the demand of food the application of new production techniques is required. Thus, a hydroponic.Hydroponics is a soilless method or technique of growing crops using mineral nutrient solutions.

Many researches was done in the field of agriculture, only monitoring the environmental factors is not the complete solution to increase the yield of crops. To increase the production and reducing the man power, automation is required in this field. Automation can be done using IoT technology. With the help of IoT in hydroponic techniques farmers can easily monitor as well as controltheir crops-temperature, humidity, light intensity, water level and pHin real time.

II. LITERATURE REVIEW

A system that fully automated hydroponic system was introduced by VaibhavPalande et al. [17] They were used open source automation software called Domoticz and the system was monitor and controlled the crops from mobile app that support on bothiOS and Android devicesThe article was mainly based on improvement and the utilization of hydroponics technique. The author S, Charumathiet al. [1] proposed a project that would control and monitor plant automatically using IOT technology. They were used Arduino Atmega328, humidity sensor, pH level, light intensity, LCD, Relay, Water spray in their proposed project. Dr. ShaliniVermani [3] stated some challenges and problems in agriculture sector faced by farmers and also gives solution that how to solveagricultural sector problems. The main objective of the paper was how to produce more food with the help ofsmart technologies such as use of drones, remote soil monitoring etc. In this paper Ms. Mamta D. Sardareet al. [12] was gives a brief information about the types of crops that cultivated in hydroponic technique. The authors also compared the ordinary soil yield and hydroponic yield and resulted hydroponic is much better than soil yield. The authorsSaraswathy et al. [8] proposed a hydroponics system that was controlled remotely sprinkler and water flow through pipeline based on data coming from the sensors. The article also stated that the hydroponic system can be controlled by applying machine learning algorithms like deep neural networks as future work in India.

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III. OBJECTIVES

- To investigate whether farmers use hydroponic techniques or not.
- To demonstrate the advantages and disadvantages of hydroponics.

These objectives can be acknowledge by validating the hypothesis stated as under:

H1: "farmers using hydroponic method for growing crops yield more profit due to healthy and high quality crops".

IV. TYPES OF HYDROPONIC TECHNIQUES

Three main typesare – 1. Nutrient film technique,2. Deep water culture technique, 3. Ebb and flow method.

A. Nutrient film technique (NFT)

It is one of the most popular technique. In this channels are built out of plastic and are lined with polyethylene plastic. A pump is used to circulate water throughout the channel. Plants are suspended above solution with the roots dangling down into the solution. The channels are slightly sloped and the water is collected and reused by pumping it back to the holding tank. Plants with large root systems that can effectively reach down into the water canbe grown using this technique.

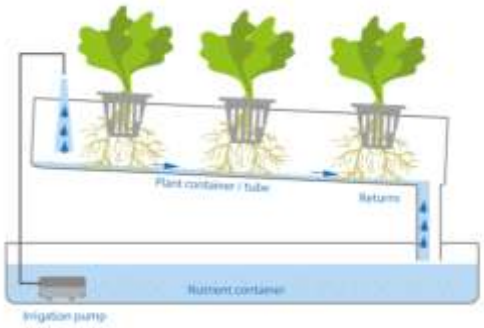

Fig.1 View of NFT system [20]

B. Deep water Culture technique (DWC)

In the technique, rooted plants are placed in net pot on top of the nutrient solution. It differs from the NFT and the DFT systems because the roots hang freely into the nutrient solution. Air bubbler can be used to oxygenate the water. Since roots are constantly supplied with nutrient solution, the plants grow quickly. This technique is simple and safe to use. This method is effective for plants such as lettuce, but not for larger plants or those that take a long time to grow such as tomatoes or cucumbers [15]

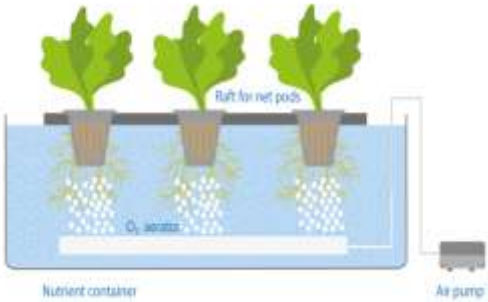

Fig.2 View of DWC technique [20]

C. Ebb and flow method

In this method water is pumped into the tank and then allowed to gradually drain. This differs from the water culture method because as the water drains, the roots are exposed and receive more oxygen. Also, cycling the water ensures that the water is less stagnate and will contain more oxygen. Careful attention must be given to the pumps because if the pumps fail, the plant roots can dry out quickly, especially in hot climates.Ebb and flow systems work best with small plants.

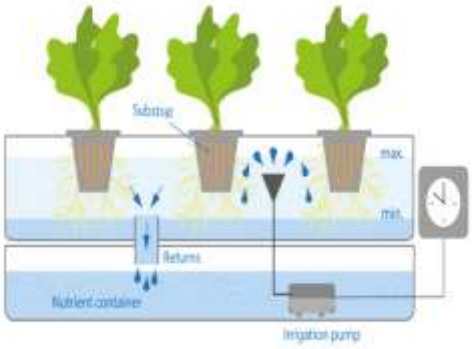

Fig.3 View of Ebb and Flow technique [20]

V. LIST OF CROPS THAT CAN BE GROWN IN HYDROPONICS

Everything ranging from flower to fruit crops to healthful plants can be fully grown using soil-less culture.

TABLE I List of Crops That Can Be Grown On Commercial Level Using Soil-Less Culture [5]

Type of crops	Name of the crops
Cereals	Oryza sativa (Rice), Zea mays (Maize)
Fruits	Fragariaananassa(Strawberry)
Vegetables	Lycopersiconesculentum(Tomato), Capsicum frutescens(Chilli),

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	Solanummelongena(Brinjal), Phaseolus vulgaris (Green bean), Beta vulgaris (Beet), Psophocarpustetragonolobus(Winged bean), Capsicum annum (Bell pepper), Brassica oleracea var. capitata(Cabbage), Brassica oleracea var. botrytis (Cauliflower), Cucumissativus(Cucumbers), Cucumismelo (Melons), Raphanussativus (Radish), Allium cepa(Onion)
Leafy vegetables	Lactuca sativa (Lettuce), Ipomoea aquatica(Kang Kong)
Condiments	Petroselinumcrispum(Parsley), Menthaspicata(Mint), Ocimumbasilicum(Sweet basil), Origanumvulgare(Oregano)
Flower / Ornamental crops	Tagetespatula(Marigold), Rosa berberifolia(Roses), Dianthus caryophyllus(Carnations), Chrysanthemum indicum (Chrysanthemum)
Medicinal crops	Aloe vera(Indian Aloe), Solenostemonscutellarioides(Coleus)
Fodder crops	Sorghum bicolor (Sorghum), Medicago sativa (Alphalfa), Hordeumvulgare(Barley), Cynodondactylon(Bermuda grass), Axonopuscompressus(Carpet grass)

VI. ROLE OF IOT IN HYDROPONICS

The IoTplays an importantrole in the automationprocess. The cultivators can recognize the situations of the plant and manage the parameters remotely, this can be easilyachieved by integrating the hydroponicsystem with IoT.

A. Block diagram

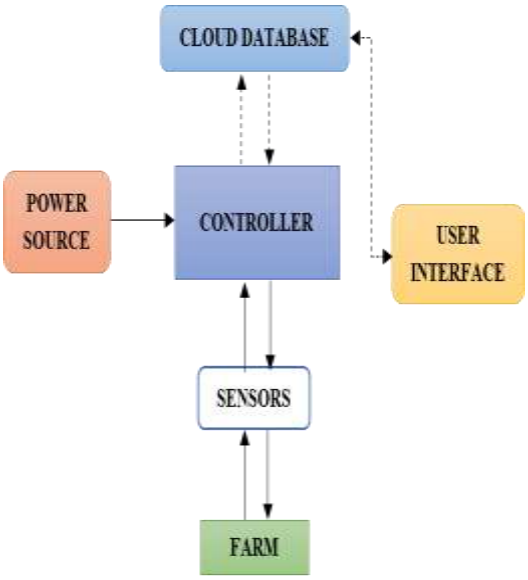

Fig.4 Block Diagram of the System

B. Working of the system

The Sensors and actuators are used to automate the hydroponicsystem, these sensorvalues

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are sent to the clouddatabase from where the cultivator is updated with realtimeinformation of the crops.The cultivator can also adjust the configuration of the sensors and actuators from the mobile application. The mobile application has all the specification about the hydroponic system, the cultivator must have a unique login ID. The user name and the password are registered with the cloud database, by this the cultivator can operate with their crop field without any interruptions. The water flow can also be controlled with the help of mobile application. By this manner the plants can be grown without any health issues.

VII. METHODOLOGY

A. Participants

This study used survey analysis based on field visit outcomes recorded in Google forms to test the proposed hypothesis.In survey there were total 40 participants (19 farmers and 21 agricultural students). The participants were randomly selected without any bias. The survey was conducted within the state limit of Maharashtra.

B. Procedure

For data collection two methods were used 1. Google form and 2. Field visit. In survey as well as in field visit various questions were asked such as what variety of crops they grow, what factors affected their yield, they have storage place or not, how they market their crops, they know hydroponic technique or not, they tried any hydroponic technique or not and lastly what they think about technology in agricultural field. By this way data was collected.

VIII. EXPERIMENT

The outcomes of survey analysisconductedby chi square test with variables (Farmers and Agricultural students) categories (yes/no)got x^2 calculated = 9.83, x^2 tabulated = 3.84 here x^2 calculated > x^2 tabulated therefore alternate hypothesis accepted i.e. farmers and agricultural student don't know about hydroponic techniques. Fig 5 shows the responses result of the survey question that was asked (Do you know about hydroponics?)

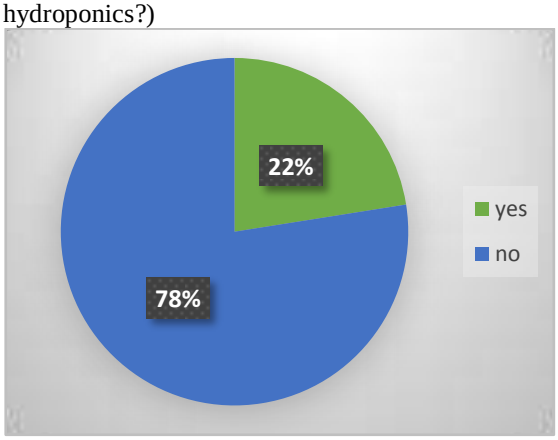

Fig.**5** Survey question responses

IX. RESULT

The test scores of paired samples rendered through survey analysis calculated using the chi square test resultednull hypothesis (participants know hydroponic techniques) was rejected and alternate hypothesis (participants don't know about hydroponic techniques) was accepted stating that the farmers and agricultural students don't know about hydroponic techniques.

X. DISCUSSION

A. Advantages of soil-less culture

There are many advantages of growing plants under soil-less culture over soil-based culture. Overall soil-less culture provides efficient nutrient regulation, higher density planting, and leading to increased yield per acre along with better quality of the produce. It is also effective for the regions of the World having scarcity of arable or fertile land for agriculture[10]. Hydroponic averages compared with ordinary soil yields are listed in table.

TABLE II Hydroponic Averages Compared With Ordinary Soil Yields [5]

Name of crop	**Hydroponic equivalent per acre**	**Agricultural average per acre**
Wheat	5,000 lb.	600 lb.
Oats	3,000 lb.	850 lb.
Rice	12,000 lb.	750-900 lb.
Maize	8,000 lb.	1,500 lb.
Soybean	1,500 lb.	600 lb.
Potato	70 tons	8 tons lb.

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Beet root	20,000 lb.	9,000 lb.
Cabbage	18,000 lb.	13,000 lb.
Peas	14,000 lb.	2,000 lb.
Tomato	180 tons	5-10 tons
Cauliflower	30,000 lb.	10-15,000 lb.
French bean	42,000 lb. of pods for eating	-
Lettuce	21,000 lb.	9,000 lb.
Lady's finger	19,000 lb.	5-8,000 lb.
Cucumber	28,000 lb.	7,000 lb.

B. Limitations of soil-less culture

Despite of many advantages, soil–less culture has some limitations also. Implementation on commercial scale requires technical knowledge and high initial investment, though returns are high [10]. Great care is required with respect to plant health control and finally, the energyinputs are necessary to make the systemwork.

C. pH level

The control of pH is extremely important, not only in hydroponics but in soil as well. Plants lose the capability to absorb different nutrients when the pH differs. An ideal pH level is between 5.5 and 7. Changing the pH level too quickly is not a good idea as this will stress the plant out too much. [1] The pH values for different soilless crops are given in Table.

TABLE III pHValues For Different Soilless Crops [5]

Vegetables	**pH Range**
Beans	6.0-6.5
Broccoli	6.0-6.5
Cabbage	6.5-7.5
Carrots	5.8-6.4
Cucumbers	5.8-6.0
Garlic	6.0-6.5
Lettuce	6.0-6.5
Onions	6.5-7.0
Peas	6.0-6.8
Pumpkin	5.0-6.5
Radish	6.0-7.0
Tomatoes	5.5-6.5

D. Future work

- Implementation of the automation in hydroponic technique will be proposed in further research paper.

XI. FUTURE SCOPE OF THIS TECHNOLOGY

Hydroponics is the fastest growing sector of agriculture, and it could very well dominate food production in the future. As population increases and land declines due to poor land management, people will turn to new technologies like hydroponics to create additional channels of crop production[4].Hydroponics also will be important to the future of the space program[12]. NASA has extensive hydroponics research plans in place, which will benefit current space exploration, as well as future, long-term colonization of Mars or the Moon[11]. As we haven't yet found soil that can support life in space, and the logistics of transporting soil via the space shuttles seems impractical, hydroponics could be key to the future of space exploration[11].

XII. CONCLUSION

The industry is expected to grow in future also thereforesoil growing crops will becoming difficult. Specially, in a country like India. In India

hydroponic technology is less used by farmers because majority of farmers don't know about this but in future the **H1**hypothesis can be accepted and with the help of IoT they can easily monitor and control their crops and make more profit compare to traditional method.

XIII. ACKNOWLEDGEMENT

A special gratitude is conveyed to Prof. Swapna Augustine Nikale, Department of Information Technology of B.K. Birla College of Arts, Science and Commerce (Autonomous) Kalyan, Thaneand all the Farmers, Agricultural students for their support and encouragement.

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