Section A-Research paper
ISSN 2063-5346

REVIEW PAPER on an Automated Hydroponics System

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doi: 10.48047/ecb/2023.12.si6.370

Abstract – Hydroponics is an old skill that starts almost 2500 years ago. It helps to save water, soil and shows higher yielding compared to conventional farming. A top part of the land of the earth is commonly used for various agricultural operations. However, in the present age, cultivatable land is progressively decreasing as compared to land available for other sectors for example industrial sector. Considering this issue, several techniques of agriculture evolved that only need a limited land and can yield all the desirable requirements of the community. One of the techniques used nowadays in farming is the hydroponics agricultural system. Hydroponics with a properly designed system is a futuristic way for agriculture that also increase sustainability to survive in unusual climatic condition. Hydroponic can also provide a substitute for organic farming. The target of this work is to carry out in this paper is to help the researcher research the marketing and various parameters necessary in hydroponics by identifying and delivering the details of this study. Further, this review paper highlights the proposed work in the various literature survey and required modifications in regards to self-acting hydroponics systems with a controlled environment, dissolve water nutrients, water supply and Air circulation. The literature review emphasizes that hydroponic systems which are well controlled and appropriately organized give better growth-rate and show a considerable reduction in human involvement.

Keywords: Hydroponics, sensors, IOT, Nutrients, water management, air Management, Cost management

1. INTRODUCTION

The world's population continues to climb at a steady pace; meanwhile, resources steadily diminish and research suggests that it is possible to reach 9.5 billion people in 2050, the current population is currently six billion, with a per capita land area of 0.25 hectares, while the projected 2050 population is expected to be 9.5 billion. Hydroponic farming is a form of agriculture that uses mineral solutions rather than it is absorbing from the soil for the growth of plants. It is a scientific solution to the problem of increasing demand for food and decreasing farmland. Hydroponic farming is known as soil-less farming, with similar techniques to create a vertical garden. The main reason why people adopted this method is that they could use less land and water resources to produce food (Muhammad E H Chowdhury et al,2019). Hydroponic systems use a nutrient-rich liquid, called the root nutrient solution, as the source of plant life.

By providing water and dissolved nutrients to plants in an environment completely controlled and monitored by computers, hydroponics provides consistent uniformity with regard to lighting, pH, and oxygen levels - allowing for maximum yields from your investment. The effectiveness of hydroponics was studied at various stages of development. Theoretical analysis collaborates efficiently with numerical analysis and experimental analysis.

Automated hydroponic system is comprised of a pot full of seedling trays and/or planter boxes, a nutrient solution reservoir, pumps, and other electronics. Parameters such as plant nutrient levels, pH levels, dissolved oxygen levels, and water temperature can be measured by sensors. The structure of a vertical farm is not just limited to the geographical location of the project, but it also depends on the agricultural design and cultivation lines. After studying the parameters such as canopy density and lighting, LED technology has played an important role in providing sufficient light for photosynthesis.

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2. RESEARCH METHODOLOGY

The objective of this review paper is to study ongoing research and approaches develop to monitor different parameters in hydroponics. The investigation is focused on both the theoretical and empirical aspects of smart farming, IoT concepts in regard to environmental aspects such as water and carbon resource management, energy conservation, and even terms of improving yields and quality. This synthesis will help to gain a better understanding of how these technologies can be used in agriculture practice. The research paper presents a logical analysis of easily accessible journal and conference papers about hydroponics systems. This data was manually analyzed to form a basis for this study. The research paper gives an overview of the growth in hydroponics and identifies key events and activities, explaining their significance.

3. Essential Parameters in hydroponics

There are independent parameters used in automated soil-less farming that have different measurement methods. For example, pH test strips fluctuate pH sensing systems, independent sensors associated with LCD screens, or sending the data by analog sensors wireless or with the help of wire to control panel like Aurdino, Rasberry-pi, PLC.etc. Automated sensing methods need to assess the accomplishment of designing a reliable, impregnable, and profitable hydroponic system. Researchers used SMART technologies to make sure of the stable operation of all the relevant parameters used in the soil-less farming (Wei et al. 2019). In the following subsections, each parameter of the hydroponic system is discussed.

3.1 Water

The most necessary factor for soil-less agriculture is the quality of water. It is also known as the 'carrier' in the hydroponic system due to its ability to dissolve nutrients and transport them to the roots of plants. Some impurities are soluble in the water which gives a negative impact on the health of plants. These impurities cannot be well detected naked eye, and it is all too easy to be misled into making wrong assumptions about the pureness of water from the clearness of a sample. Then, clean water is a must for healthy plant growth. Water quality problems are often simple to solve provided they are properly identified. It is hypothetically essential to preserve the precise pH, temperature, dissolved oxygen, salts, Air humidity, and light intensity throughout the whole procedure. ("Lab Water Purification Systems", 2021). Media grow bed in hydroponics system shows higher productivity and is most suitable for leafy green vegetables than "Deep Water Culture (DWC)" and "Nutrient Film Technique (NFT)" (media grow beds > DWC > NFT) (A. C. Bandi Victor, 2016).

3.1.1. pH

One of the most significant hydroponic excellence variables in hydroponic schemes is pH. The term pH stands for the control of hydrogen and mentions the attentiveness of hydrogen ions in an answer. Absorption of the essential nutrients will become difficult if the pH level attains an extreme level which ultimately shows an adverse effect on the health of plants. Some plants grow comfortably in acidic conditions of water while some plants need an alkaline condition for their growing media. Leaving few special cases, the favorable value of pH range between 5.5 to 6 for the crop grown in a hydroponic system. Fruits and vegetables namely melons, apples, beans, squash, and tomatoes prefer a pH range of 5.5 to 6. Whereas Blueberries require a pH value having a range between 4.0 to 5.0 which is the acidic solution (Judith, 2019).

3.1.2 Temperature

The temperature of the water plays a crucial role in the hydroponic system. The temperature range between 18 to 26 0C (i.e 65 and 80 degrees Fahrenheit) is the most favorable temperature of water for plant life. Researchers have found that dissolved nutrients show the best results when the temperature of hydroponic water is kept between 65 and 80 degrees Fahrenheit. Researchers prefer and suggested that solution and solvent should have the same temperature. Plants' roots will experience sudden shock if there is a difference in the temperature of the water and added nutrient solution which ultimately results in the death of the plants. Aquarium heaters were used to regulate hydroponic water and nutrient solution temperature in cold seasons. Similarly, it is recommended by the researcher the availability of an aquarium chiller if summer temperatures surge ("London Grow" Jan 31, 2020). However, rhizomes plants like ginger grow healthier in warmer conditions. For that reason, the water temperature is kept between 71° and 86° Fahrenheit or 21.6° and 30.0°Celsius. (Domingues, D.S., et al. 2012).

3.1.3 Dissolved oxygen

In hydroponic systems, regular oxygenation of the water where roots are submerged is very important to make sure good health of the plant. Recommended Dissolved Oxygen (DO) is to be 5 mg/L or above suggested by the researchers, if the DO level falls below the designated value then it causes serious damage to plants and perhaps causes death to the plants. However, it is very challenging to maintain a DO level concentration of 5 mg/L in a hydroponic system. Dissolved oxygen in the solution of a hydroponic system decreases correspondingly as the temperature of water increases. As the increase in temperatures of the hydroponic system causes low DO solubility, and moreover increase in root respiration and oxygen intake. Oxygenation in the water can be achieved by using air pumps, air-stone, and oxygen diffuser, additions of supplementary chemicals such as hydrogen peroxide, or by manual stirring. (DO sensor hanna instruments, 2015).

3.1.4 Electro-conductivity

Electrical Conductivity (EC) measures the ability to pass an electric current through the solution and the Electrical conductivity of a solution is directly related to the content of dissolved salt in the solution. So correspondingly EC increases when salt content increases and vice-versa. EC should be kept between 1.2dS/m and 2.0dS/m. Ions of Dissolved salt present in the mixture have dissimilar specific conductivity and the ions of dissolved salts that are used to determine pH values have a hundred times more specific electrical conductivity. As a result value of EC for the same solution is completely different for different pH values. As a result, Researchers try to repeat the same values of EC and solution concentrations for many weeks but fail to get success in making the same solution of the pH and EC which was required for the plant. (Hardeep Singh, 2016) suggested the method of mixing nutrients in the hydroponic solution, the researcher ensures the value of pH is intact then the EC sensor probe can help to regenerate the previous nutrient solution. If the EC value falls considerably from the original value (70% of the original value) then the solution is not suitable for the plant and the solution should be replaced with a new solution. The ideal EC to cultivate ginger hydroponically is found to be 2.5 dS/m. ("How to grow ginger hydroponically (Complete beginner guide)", 2020). (Jerônimo L., et al, 2005) conducts the experiments on five samples with different salinity. Electrical conductivity for these five samples are 0.8, 1.93, 2.18, 3.73, and 4.72 dS/m and given sample names as T1, T2, T3, T4, and T5. Nutrients mix water solution supplied to plant for 15 minutes. It's having intervals of 90 minutes in the daytime while it's having 420 minutes gap in the nighttime. The number of leaves and stem and root dry mass was the same irrespective of different EC. The dry mass of leaves gave a 24.4% hike from T1 to T3, and shoot fresh mass increased 28.5% from T1 to T2 and then decreases 16.5% from T2 to T5.

3.1.5 Total dissolved solids

Water is capable of organic and inorganic compounds and minerals, therefore, water is also known as the universal solvent. The quantity of dissolved minerals in water is measured in terms of Total Dissolve Solids (TDS). The term TDS does not rectify the impurity dissolved in the water. It is used in the context of measuring water quality and freshness of the water. TDS will give a number of solids dissolved in the solution of water but not the impurities dissolved in the water. All water bodies contain dissolved minerals and salts like calcium, magnesium, and chloride ions. ("Hydroponics vs. Aquaponics – A Complete, and Honest Comparison", 2022). The value of TDS for the plant developed by hydroponic should be below1000 PPM.(D. Adidrana and N. Surantha, 2019).

3.2 Environment Factor

3.2.1 Air Temperature and relative humidity

For proper growth of the plant requires atmospheric temperature and humidity in appropriate proportion. The temperature required for the vegetative phase is around 25 degrees Celsius while for the flowering phase it should be 28 degrees Celsius. Relative humidity should be in the range of 60-70% for the vegetative phase while for the flowering phase plants require 40-50% of humidity. Plant growth depends on the biochemical process for complete growth. The process works at the optimal rate when the atmospheric temperature and relative humidity are under the ideal range of photosynthesis. Researchers suggested keeping sunlight, Co2 levels, O2, water, temperature, and nutrients within the growing space on priority for the overall maturation of the plant. (Understanding optimum Temperature and Humidity for Plants Grow Environment, 2020).

3.2.2 Spacing

When using a hydroponic system, root space is not much of a concern. Roots can grow without compromising plant health. Preferably, for ginger, each plant should be at a distance of 12inch. This spacing will give the ginger sufficient space to grow. (Growing ginger hydrophonically, hydroponic nutrients- Agrifarming, 2021).

3.2.3 Light Intensity

For hydroponic systems, natural sunlight shows good results for the overall development of the plant's health. However, Artificial lights can be used to complete the photosynthesis requirement of the plant in an indoor hydroponic system. The selection of artificial light is an important parameter for hydroponic systems because plants soak up light wavelengths at either end of the light spectrum which is not visible to the naked eye. The photosynthesis process is feasible in the visible light spectrum, and it should have wavelengths in the range of 400 to 700 nanometers. Research at the University of Minnesota proposed light spectrum of 445 nanometers (blue) and 650 nanometers (red) are required the most for the photosynthesis process. (Julie Weisenhorn and Natalie Hoidal, Extension horticulture educators, 2020). Likewise, the plants that are exposed to light having a ratio of the red spectrum to blue spectrum greater than 3 for 16 hours with an eight-hour break before their next exposure shows the better results (Pennisi, G., Orsini, F., Blasioli, S. et al.,2019).

4 Air Management system

Crop production shows a high yield when the system is properly ventilated. Researchers (Jun Gu Lee et al., 2013) conducts the experiment for showcasing the results of horizontal airflow rates at 0.28 m/s (Low), 0.55 m/s (Medium), and 1.04 m/s (High). These experiments showed that steady airflow application along cultivation beds in a horizontal direction is proven to be more beneficial as compared to decreasing air temperature. Low atmospheric temperature and low light intensity with medium air flow rate are preferred in the hydroponic systems to avoid leaves tip burn. This also declines the productivity of harvested plants as the rate of the photosynthesis process decreases. Thus to analyze the airflow in a hydroponic system 3-D computational fluid dynamics (CFD) model simulated the habitat in a rack. In numerical analysis, the air ventilation system is designed with a dynamic and uniform boundary layer that prevents tip burn in plant growth. Vertical airflow is provided by the three rows of air tubes. Four cases to optimize mean air velocity and coefficient were studied by the researcher (Ying Zhang et al., 2016) under controlled parameters of hydroponics. From the results of all cases, the researcher recommended two air tubes with a mean velocity of air of 0.42 m/s and a coefficient of variation is 44% giving the optimal design for constructing an air ventilation system in the hydroponics study.

5 Automation of hydroponics system

Vast knowledge delivered by the researcher in the field of automation in hydroponics. The approach to studying various parameters varies from system to system. A major portion of the automation of hydroponics consists of automation in delivering nutrients, maintaining temperature, pH, Flow of nutrients, and light intensity. In soil-less farming Sensing of different parameters can be performed such as calculating the pH value, moisture content, EC value, and atmospheric temperature and after sensing all the relevant data controlling systems such as the Micro-controller Arduino-Nano will use to process data. Thereafter controlling system generates the output signals and devices like the motor pump set, sprinkler, conveyor belt, and solenoid valve for nutrients supply follow the signals. All these systems are activated after a particular time interval (Soniya Joshi et al., 2018). Instead of nozzle some author uses atomize nozzle as a regular base to give nutrients and desire moisture in the form of fog at regular intervals. All essential parameter required for the system is controlled at regular interval for proper growth of the plant (Imran Ali Lakhiar et al, 2018). (Diego S. Domingues et al., 2012 repeat) has developed an automated software that monitors electrical conductivity and pH values for 24 h. it also permits solenoid valves to control the content of nutrients and pH in the hydroponic solution. Micro-controller acts as a processing unit where it takes valuable information from the sensor and if the solution shows any fluctuation within the mentioned range then the micro-controller will initiate its processing and corrects the values for pH, EC, Temperature, etc. While establishing the relationship between temperature and pH. It comes into the observance of the author that pH and temperature are inversely proportional to each other. Water in a hydroponic system gets more acidic i.e the value of pH decreases if the temperature of water increases. An increase in the temperature of 10^0 C will give result in a decrease in pH by 0.06.

Internet on things plays ital role in automation of hydroponic system. PH and air quality index are observed with the help of IoT devices. It gives a warning alarm when the automated hydroponic system loses its standard condition. Similarly for tracking the relevant data from IoT devices provides flexibility to farmers. (B S Shubhashree et al, 2020) researchers developed an application that works on the android operating system. To access portable information (Dr.D.Saraswathi et al., 2018) have evolved a system based on IoT that shifts the regain hydroponic data to the internet. Android apps in mobile use the hydroponics data to intimate the ultimate user. The researcher further contributed his work on intelligent hydroponic systems monitored by IoT platforms and robotic culture in a hydroponics system. The Internet of things (IoT) helps to stock up on data and present the data graphically at the remote location. This can help the user with real-time information on crop growth conditions, which is helpful in optimizing crop production and improving yield (Palande V. et al, 2017). (Muhammad E H Chowdhury et al., 2020) exhibits all the parameters on the thingspeak which is IoT based platform. The researcher facilitated monitoring and inspection of various parameters of the hydroponic system by the web interface. Provision for sending the SMS message to the user's mobile for any interruption on the working of the motor pump. Data extracted from the web source were used for the machine learning algorithm and deep learning algorithm for controlling hydroponics systems in a mechanized way. (Dr. Asawari Dudwadkar et al., 2020) develops solutions for distance monitoring . Its hardware contains various type of sensor and actuators which helps to process pH, Humidity, Temperature, etc. Develop applications that can easily run and operate on smartphones. Arduinos and Raspberry Pi usage by the firm named Titan smarphonics for developing the hydroponics software fully automatically. (Brewster C. et. Al. 2017) suggested the new business models, protection against a security breach, protection of privacy, and data governance.He also suggested the hurdles and limitations of developing an IoT-based system deployed on a Large scale. Artificial lighting such as LED for the photosynthesis process were studied and experiments had been carried out on selected species under the Stonecrop family. Results indicate artificial lights for 16 hours are more effective and productive (Sang Yong et al., 2016).

Nutrient solution induction(Paolo Sambo et al. Et al., 2019) highlights the mechanism to circulate adequate nutrients to the plant. Mechanisms deliver a sufficient amount of nutrients to enhance the quality of plants. Researcher promotes the use of nano-particles and bacteria like rhizobacteria in hydroponics system to ensure the fitness of plant health. To ensure the presence of nutrients in the hydroponic solution researcher works on the machine learning logic. Interpretation of the data collected by the sensor and analyzing the data to give output. The machine learning algorithm is used to modify the composition of nutrient solutions on real-time analysis of the data. (Lenord Melvix J.S.M, & Sridevi C. 2014) formulate the fitness function on the Fuzzy Inference System (FIS) to control the induction of nutrient solution in a hydroponic system. Parameters that control the flow of nutrient solutions are optimized with the help of a genetic algorithm. The convergence error function uses to minimize the error in FIS. A researcher named (Alejandro Isabel et al., 2019) perform explicit works on fault detection hydroponic system by the neural network, Microcontroller pH fuzzy logic control system with the real-time operating system for injecting the nutrients in the solution. A controlled cultivation system is used to produce a soluble synthetic fertilizer as well as a soil-less crop. The aim of the researcher is to grow tomatoes under drip irrigation with fertigation. And results show Tomato yields per plant of 2.16 kg per plant and for 1 hector it gives around 112 Tonnes of tomatoes (Dr. Umesh Barikar et al, 2013).

6. Data processing

Automation in hydroponics by using various sensors with a closed feedback loop system were design to decide important parameters without manual intervention. Users can easily keep track of the plants and sensor readings with the android application. The application provides users with information about the plants, air quality, and observation cameras. Data recorded from the sensor is shown on the android phone to the farmer, henceforth the system works constantly and continuously for better results and maximum profit.

(P Sihombing et al., 2017) works on ultrasonic sensor HC-SR04 to find the level of dissolve nutrients and sensor LM35 to detect fluctuation in the temperature. Sensors will gather the data and it will send to the micro-controller like Arduino Uno by a wireless WIFI module (ESP8266). After processing, the data is displayed on the Liquid crystal display. Nutrient solution flow is controlled automatically by the Ardunio Uno microcontroller using the if-else command. Users can monitor the data around the hydroponic system through an Android smartphone.

(S. Adhau et al., 2017) works on the import of data through an AVR micro-controller board in real-time. The researcher use NI Labview for surveillance of the data. It is also used to computerize all the processes of hydroponic systems in real-time. IoT applications receive the data from the source with the help of a network. The overall device is a low-cost device and controlled by tunning of PID.

(Monteiro, J. et al. 2018) presented his work on digital twins for vertical farming. It is the synchronization of the physical state and digital layers of IoT. The system makes self-arrangements for any climatic change, continuous self-rotation, and energy saving. It can also perform self-optimization learning from data received from multiple sources. Forecasting of the data will support decision-

making. (K. P. Ferentinos et. al. 2002) forecast the value of pH and the value of electrical conductivity (EC) requires in the root of lettuce. For forecasting researcher took nine inputs required for the plant growth (like pH, EC, nutrient solution temperature, air temperature, relative humidity, light intensity, plant age, amount of added acid, and amount of added base) and presented outputs as pH with EC with the help of a neural network algorithm. Data points were trained by the quasi-Newton back-propagation algorithm. PH level and EC level values are forecast for the time span of 20 mins keeping intervals of 0.01 units and 5 S/cm correspondingly.
To study the effect of a variety of seeds and planting systems (Raneem Gashgari et al., 2018) two different types of seeds were experimented with for 30 days. The observation was analyzed by software Design-Expert and performed variance test (ANOVA). While studying the interaction between the planting system and the type of seed a researcher found that the growth of the plant was not affected by the type of seed whereas it affected from the planting system. After comparison, hydroponic system gives higher development of plants than traditional farming.
(Sreedevi, T. R. et. Al. 2020) studied the new approach of Digital Twin (DT). Digital Twin is an artificially intelligent software system. In this research, Digital Twin is an application that runs on a server in a home. The DT refers to the phase as a distinct property of matter that is studied as a subject of science in turn as plants and animals grow, develop and die. A DT provides an accurate representation or model of the real world for deep learning applications such as robotic automation.
The work by (Dolci, R. (2017) focuses on Malthouse Malting, where the malting process involves the careful adjustment of CO2, Temperature, and Humidity. After processing of the data, AI suggests the most suitable schedule for the routine of the plant. This helps improve the final product through increased content of starch and proteins. The cultivation of medical marijuana is also examined in detail. Having 138 variables that require a great deal of attention and tuning, it was important for the AI system to support this process as well. The results showed significant increase content of starch, protein, and alcohol content.

7 Nutrients

130,000 square feet of land were the largest vertical farms available in Dubai. Every day it cultivates 6000 pounds of food. It consumes (1/2500) the amount of water as compared with conventional farming. The city imports 85% of its food. Soil-less farming will increase the adaptability in desertified region ("Hydroponics: The power of water to grow food", 2019).
(J.E. Rakocy et al.,2005) introduce the thirteen nutrients inducted into the hydroponic system for lettuce growth. Thirteen nutrients are Ca, Mg, K, NH4, NO3, PO4, SO4, Fe, Mn, Zn, Cu, B, and Mo. (Nguyen NT et al., 2016) studied different types of minerals present in the roots and shoots of plants. Nitrogen (N), Phosphorus (P), Potash (K), Calcium, Sulfur (S), and Magnesium were found in shoots relatively more than that in roots. Micronutrients like Iron (Fe), Zinc (Zn), Copper, Boron, Manganese Molybdenum, Chloride, and Cadmium were present in the roots abundantly. Researchers suggested and carried out all experiments in a cold room has a temperature of 4^0C.
(David Sanjuan et al., 2020) use the method of re-circulation of nutrient solution in order to decrease the draining out of the minerals from the hydroponic system. It is found that the hydroponic system loses nutrients (almost 51 % of the average nutrients required by the plant) while it is able to retain in the substrate (perlite) where nutrients consist of macro elements such as calcium, nitrogen, and phosphorus with 5%, 6%, and 7% respectively. Retention of phosphorus and calcium in the hydroponics system was presented by a regression model.
Nitrate can easily remove by the floating and gravel bed treatment as compared to NFT treatment. It's found 20% more efficient. The phosphate removal rate is the same in both treatments. Similarly dissolved oxygen, replacement of water and electrical conductivity have the same removal rates in both treatments. So researchers (Wilson A. et al., 2006) concluded that the floating and gravel method should be preferred for withdrawing of minerals present in aquaculture.
(Rufí-Salís et. Al. 2020) promotes the re-circulation of nutrients in order to reuse Macro-nutrients and micro-nutrients in the hydroponic system made for growing tomato plants. He used direct leachate recirculation(DLR), chemical precipitation(CP), and membrane filtration(MF) methods for supplying the nutrient-rich solution. (Tavakkoli et. al. 2010) focuses on the salinity concentration in the hydroponic system. Researchers experimented by increasing the concentration of Na+ and Cl– in hydroponics and in traditional farming under identical electrical conductivity. Barley plants were taken for this experiment. Results show that growth reduction is more in hydroponics than in traditional farming. So the containment of the salts was an important parameter for soil-less farming.

8 Water management.

Water management in a hydroponics system is managed by re-circulation of the hydroponic solution to recover the nutrients. Re-circulation of the hydroponics solution can prove more viable to another variable crop. After treatment of the nutrient-saturated water nutrients like N, P, and K can be removed easily from hydroponics water solution which stops water pollution and water deficiency (Liliana Cifuentes et al., 2020). (Alexa Bliedung et al., 2020) works on the plant where water treatment will be performed along with growing the plants hydroponically. Water should be preheated before water treatment so that all the nutrients from the wastewater get removed to avoid nutritional water supply to the hydroponic system. Researchers use different water treatment methods like "Activated sludge method, Zonation and Biological Activated Carbon Filtration". He uses to feed and depletes in the Hydroponic plant. Infeed and deplete system wastewater is treated with nitrogen concentration greater than 40mg/liter. (Carmelo Maucieri et al., 2018) studied flow-through and feed & deplete mode for hydroponic pilot plants. Researcher state irrespective of nutrient concentration in the wastewater both mode of operation works satisfactorily with respect to plant weight. Recirculation is another possible way to reduce and reuse wastewater in a hydroponics system. (N. Sigrimis et al., 2001) works on supplying the water hourly basis. He supplied 10 min of nutrient-mixed water every 70 min. On daily basis, the researcher supplied nutrients in mixed water for 11 to 13 hours. Reducing water pumping in the hydroponic system benefits economically to environmentally. The Aquaponics system shows good performance for fish growth, plant growth, and removal of nutrients when the reusing of treated water flows from 0.8liter/min. To 8.0 liter/min.

(A. Anastasiou et al., 2019) develops optimization methods for irrigation and nutrient supply by greenhouse climate. In the model, water losses are used and the model will sense it by various sensors such as a drain measurement device, and soil moisture meter. After sensing model uses an application that can optimize the output error linearly or non-linearly. (Marwan Haddad et al., 2011) promotes decentralization of wastewater treatment plants for being cheap to construct, working, require less maintenance with long life. The researcher uses barrels or channels for making the structure of the hydroponic system. After three years of designing and testing he found that removal of BOD (biochemical oxygen demand) is 93% to 96%, COD (chemical oxygen demand) is 80% to 89% and total nitrogen is 62% to 65%. he further concluded the research that green bean was unable to grow in sewer water. Plant yield and plant growth were best in the hydroponics barrel system rather than the hydroponic horizontal channels system.

(Guilherme Lages Barbosa et al., 2015) compare the production of lettuce plants in conventional farming and Hydroponic farming. Hydroponic systems at 815 m^2 produce 41 kg per m^2 in a single yield with a standard deviation of 6.1 kg per m^2 in a single yield. It consumes water at 20 L per kg in a single yield and energy at 90000KJ per kg in a single yield with a standard deviation of 3.8 L per kg in a single yield and 11000 KJ per kg in a single yield. Whereas in conventional farming with the same area lettuce production is 3.9 kg per m^2 in a single yield with a standard deviation of 0.21 kg per m^2 in a single yield. Conventional farming requires water of 250 L per kg in a single yield and energy of 110 KJ per kg in a single yield with a standard deviation of 25 L per kg in a single yield and 75 KJ per kg in a single yield.

9 Cost management

Automation of the hydroponics system is an expensive parameter. It also consists of monitoring by a specialist person. Functions like pest control and prevention of diseases took a lot of attention which results in adding more cost to the production of plants in a hydroponic system. Collecting all the information from the hydroponic system and after critical analysis of data, the control panel will process the data. For all, this function farmer is not familiar with the management of software. Therefore (Souza S.V. et al., 2019) suggest the innovation of a user-friendly application that will be helpful for the agriculturalist to record all data of the system and also help to improve the decision-making of the farmer. (Prafulla Kumar Naik et al., 2012) studies the cost of seed utilized, electricity, water, and detergent consumed, manpower required, and hydroponics fodder biomass produced was recorded for Two varieties of maize seeds I e CT-818 (yellow maize) and GM-4 (white maize). The daily total cost was Rs. 1557.80/- and Rs. 2187.80/- for CT-813 and GM-4, respectively. It can be concluded that the cost of growing 1 kg of green fodder maize hydroponically (on a fresh basis) ranged from Rs.4.59 to Rs.5.09, depending upon the variety of seed and the cost of production is approximately Rs.0.50 Cower in GM-4 (white maize) seed than the CT-818 (yellow maize) seed.

To reduce the operating cost researcher (Johanna Suhl et al., 2016) use Double Recirculating Aquaponic System (DRAPS). Researchers yielded tomatoes with a range of 46.1Kg to 47.7 Kg and tilapia fish of 1.5 kg in the aquaponic system. Fertilizer works up to 23.6% efficiently in DRAPS. (Benke, K., & Tomkins, B., 2017) speaks about the ever-rising economy in soil-less vertical farming. The cost is drastically reduced by nullifying external disturbances earthquakes, floods, drought, etc, and reduces the requirement for other supplements like fertilizer, and pesticides which results in a profit margin. The production of plants is localized therefore cost of transportation machinery such as tractors, trucks, etc reduces. As hydroponic farming is independent of seasonal change farmers can gain surplus profit from the system.

10 Basic components use in hydroponic system

The materials and parts necessary to build the base hydroponic system that can use to grow crops are Grow Tent, Grow Light, PVC Pipe, PVC Pipe, PVC End Cap, Submersible Water Pump, Plant Growth Nutrient Solutions, pH Adjustment Solutions (Up/Base and Down/Acid) and for making system, fully automated motherboard and sensor namely Arduino, PH Sensor, EC Sensor, Air Temperature & Humidity Sensor, Water Flow rate Sensor, Water Temperature Sensor, Water Filtration System, Water Cooling System, Light Intensity can be used. The plants grow in a Flood and Drain type of hydroponic system and are planted in a grow bed filled with growing medium and nutrient solutions. Water will then be pumped into the grow bed, and the flow of water will discontinue automatically. Once this process is completed, the grow bed will then be drained of water, and the water will flow back into the pump i.e.to the water container. (Nisha Sharma et.al, 2019)

11 Advantages

Hydroponics is preferable where convectional land or fertile land is not available for farming. Farming can able to be done in a more controlled way and with the analysis of data immediate decisions are taken in a more effective manner. Installment cost of hydroponic system is more. After installation running costs and maintenance costs are less compared to conventional farming. Planting more trees in a small space is possible. The growth of the roots is controlled as they can easily absorb nutrients easily, So roots grow shorter. Maintenance time is significantly reduced in hydroponic indoor farming. Weed doesn't grow. Even in urban areas, hydroponic Plants can be grown on rooftops, window shelves, corridors, garages, bedrooms, and living rooms. Hydroponic plants can grow up to 50 percent faster, which is going to fulfill the needs of the future population demand.

12 Disadvantages

The major disadvantage of hydroponics is the need for experts in handling the automated hydroponic system. Human resources with good knowledge of the sensors and controller are required. Proper surveillance is needed in the preparation of formulas to analyze the data, Nutrient mixing procedures, and plant health control. The initial cost of a hydroponic system is more.

13 Applications

Hydroponics system has vast application in house gardening indoor gardening, and Growing medical plants. Alteration of the nutrients containing or changing the properties of plants is possible, no need for additional expenditure on pest control. Hydroponic systems can be used in vertical direction or horizontal directions due to this arrangement it can cultivate more plants in a small space. The hydroponic system is more suitable for countries that are more reliable on imports of basic needs due to arid regions.

14 Results

The proposed work is focused on the different aspects of hydroponics like automation in hydroponics, water management, and air management in the hydroponics system, and in-depth knowledge of nutrient and cost management in the hydroponics system. The concept of artificial lightening, minerals analysis, and various types of crops grown in hydroponic systems was explained.

15 Conclusions

This paper aims to fill the gap between engineering and agriculture. Knowledge of automation, neural network, IoT, and SMART use in the hydroponic system get familiarized to agriculturalists. Detailed knowledge of nutrients and biological activities present in the hydroponic system gets familiar to Mechanical, Electrical, and electronics engineers. This paper presents the consolidated work in the field of hydroponics. Systematic work helps the researcher to attract their attention and increase their contributions to the field of hydroponics. Human involvement is needed to start the automated hydroponic system and thereafter brain of the system i.e micro-controller will take over the charge. Micro-controller creates a comfortable environment for the growth of healthy plants. The Hydroponic is the cleaner and more sustainable source of farming that fulfill the ever-increasing demand for food in the world.

16 Declaration of competing interest

The author like to declare that the content presented in this paper is doesn't influence by any personal relation. And also like to disclose that it doesn't receive any financial help from anyone.

paper

17 References

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