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SMART URBAN FARMING APPLICATION: UV LIGHT IN HYDROPONIC INSTALLATIONS

HERRY SAPUTRA[1,*], IRFAN DWIGUNA SUMITRA[2], DEDENG HIRAWAN[2], RUDHI LESMANA[3], EDDY SOERYANTO SOEGOTO[3]

[1]Department of Information System, Universitas Komputer Indonesia, Indonesia
[2]Department of Informatic Engineering, Universitas Komputer Indonesia, Indonesia
[3]Department of Management, Universitas Komputer Indonesia, Indonesia
*Corresponding Author: herry.saputra@email.unikom.ac.id

Abstract

Hydroponic farming is an innovative method of cultivating plants without soil media. It has become a popular solution to address limited agricultural land, especially in urban areas. Indoor hydroponics is a type of hydroponic farming that involves growing plants in a room that lacks natural sunlight. Instead, Ultraviolet (UV) lights are used to ensure that the plants receive sufficient light. The goal of this research is to investigate how UV radiation affects plants in hydroponic growth systems when they are grown in a room with little sunlight. The study used quantitative methods with data collection techniques based on observation. The hydroponic plants were exposed to UV radiation during their growing period, and their growth was closely monitored. The findings of this study indicate that when plants are grown in a closed room exposed to UV light, they exhibit optimal growth due to proper light intake and nutrient maintenance. A consistent irrigation system and UV lighting have a positive impact on the shape and quality of the plants' roots and leaves, making them healthier and stronger. This is because plants' UV light requirements can still be met even when they are kept indoors.

Keywords: Agriculture, Hydroponic, Smart farming, Urban farming, UV light.

1. Introduction

The issues of food production in the twenty-first century are becoming increasingly relevant topics as the world's population grows year after year. According to Food and Agriculture Organization, the world's population will reach 9.6 billion by 2050. It means that agricultural production will have to expand by 70% in that year to meet the population's food needs [1]. However, a long-standing food problem is that the population continues to grow while the amount of agricultural area available decreases.

Urban farming is the concept of diverting conventional agriculture into urban agriculture, which differs in terms of actors and planting media [2]. The difference is that traditional agriculture is more concerned with production results, whereas urban farming is more concerned with the behavioral characteristics of urban communities. Because of the increased knowledge of healthy urban behavior, urban farming has become a lifestyle [3]. Hydroponics is a type of urban farming that uses water as a growing medium. This method is less harmful to the environment than traditional soil-based methods [2]. In locations where there is a scarcity of green space, this strategy is very beneficial. The hydroponic gardening cultivation technique has the advantage of not producing waste that is harmful to the soil and environment. More regulated release of nutrients and insecticides, greater seed health, substrates with better water retention capacities, more efficient recycling of agricultural waste, and proper plant health monitoring can be achieved with hydroponics [4]. The hydroponic urban gardening movement gives urban people the opportunity to cultivate their own crops and eat healthier food. Urban gardening is also a technique for solving food shortages, reducing environmental impacts from herbicide and pesticide use, and reducing food waste [5]. Agricultural goods from urban farming, while beneficial, will not be enough to meet future food needs because the solutions supplied by urban farming are essentially the same as adding additional land. However, how to increase agricultural production without additional land must be considered.

The term “smart farming” aims to optimize agricultural land by using modern equipment in a sustainable manner to obtain the best outcomes in quantity, quality, and financial returns. Smart farming makes use of technologies like Machine Learning, Big Data, and the Internet of Things (IoT) to increase the amount and quality of agricultural produce at all levels and scales [6]. In the future, smart farming is expected to be a required idea in agriculture. Smart farming is predicted to be a mandatory concept of agriculture in the future. This makes it possible to overcome the challenges of food production demand and labor reduction [7, 8]. An example of implementing smart farming is using various types of sensors to collect data such as humidity, light, temperature, pressure, etc. Smart farming devices give data that can help enhance productivity and reduce waste by allowing the proper actions to be taken at the right time, quantity, and location [9].

Hydroponic cultivation systems can be done outdoors or indoors. The management of water and plant light is the most critical aspect of a hydroponic system [10]. In indoor hydroponic systems, lighting sources from sunlight are almost very difficult to obtain. In indoor hydroponics, customized lighting can be used to replace the need for sunlight. UV lights can be used as a substitute for sunlight, allowing photosynthesis to take place even if the plants are kept in a closed room. Every day, 14-16 hours of irradiation is required for plants to grow optimally, particularly for vegetables and fruits [11].

Academics from many perspectives have conducted several relevant studies in recent years with the goal of giving improvements in smart farming. Kyaw et al. developed a smart aquaponic idea, which is a combined automatic integrated growing system for fisheries and plants in the same container. The system's goal is to use a water circulation system to provide water for each commodity [12]. In addition, Podder et al. [13] conducted research on the use of IoT technology in smart agrotech systems in urban farming. The system is in charge of deciding when irrigation actions should be started and stopped and has remote monitoring facilities to farm owners.

The goal of this study is to see how UV radiation affected indoor hydroponic farming plants and what effect it had. Quantitative analysis was used, which was based on the results of direct observations of plant growth from seeding phase to harvest. The hydroponic system uses an Internet of Things-based system with a Raspberry Pi sensor. PH, nutrition (ppm), temperature, and humidity from plants are collected by this system from the growing period until harvest. We can also utilize the system to remotely monitor plant conditions using smartphones or desktop computers.

2. Literature review

2.1. Smart urban farming

The concept of "Everything is Connected to Everything" has spread to various aspects of life due to the various benefits obtained, such as being able to monitor the status of the environment, health, and even work in real-time [14]. In the future, smart urban farming is predicted to become a mandatory idea in agriculture for all communities, particularly in urban areas. The purpose of smart urban farming is to utilize narrow land that is carried out by the community amid an urban environment equipped with platforms that are connected to technological devices such as tablets or smartphones [15].

Smart urban farming has many positive impacts on urban communities, such as maintaining sustainable living in urban areas, creating a green environment free from pollution, and maintaining food security. If urban farming continues to develop in an urban environment, the availability of food in the city will be fulfilled [16].

2.2. Hydroponic

Hydroponic gardening techniques are fast becoming a viable and widely acknowledged alternative agricultural method, driven by the issues faced by climate change, rising population growth, and worldwide food insecurity [17]. Hydroponics is an agricultural cultivation technique that does not use soil media. Hydroponics is an agricultural activity that uses water as a substitute for soil and dissolved nutrients. Hydroponic techniques allow agricultural actors to take advantage of narrow land, such as in urban environments. This technique provides many advantages, including faster growth, high productivity, easy handling, and better water use efficiency [18]. Cultivation of plants with a hydroponic system does not require a large area to carry it out; it only needs a small area such as a yard, the roof of a house, or others [19].

A plant will be able to flourish healthily wherever it is grown if the nutrients it requires are constantly provided [20]. In this context, the role of soil is to support plants, and the existing water acts as a solvent for nutrients, which can then be absorbed by plants. The Nutrient Film Technique (NFT) is the approach most commonly employed in hydroponic jargon among the numerous hydroponic systems. The way this NFT system works is by continuously dissolving nutrients in the water. Nutrients flow in the pipe through the plant roots and back again to the water reservoir [21].

2.3. Ultraviolet light

Ultraviolet (UV) radiation is electromagnetic radiation that comes from the sun. Ultraviolet radiation has three types of radiation rays, which are divided by wavelength. UVA rays have a wavelength of 315–400 nm, the longest wavelength among other UV rays. UVA rays are responsible for 95% of all ultraviolet rays that reach the earth. UVB light has a wavelength of 280–315 nm. UVB rays can be absorbed by clouds and cannot penetrate glass, but their range of exposure can reach the epidermis of the skin. UVB can cause red, sore, and burning skin. UVC rays have the shortest wavelength of 180–280 nm and are the most harmful ultraviolet rays to the skin. However, UVC rays cannot penetrate the ozone layer, so they cannot reach the earth's surface.

UV rays provide various health advantages when used at the appropriate levels, including stimulating the immune system, curing skin illnesses, enhancing sleep quality, and lowering the risk of cancer as well as for plants [22]. Photosynthesis creates food molecules like carbohydrates and can be aided by UV light [23]. Plants with leaf green compounds (chlorophyll), algae, and a variety of microbes are involved in the cooking process of this cuisine. Farmers can use UV light to address the UV demands of their crops, especially in areas where sunshine is scarce. UV LED bulbs, rather than sunshine, are the answer. Plants can obtain the nutrients they need while still getting adequate light using UV lights

3. Methodology

The research method used was quantitative analysis with data collection techniques through observation. The study was conducted at the Smart Urban Farming lab at Universitas Komputer Indonesia. Tests were done on vegetable plants cultivated hydroponically with indoor treatment for 30 days from planting to harvest. UV lamps were installed in hydroponic devices, and they were exposed to UV light for 16 hours every day. pH, temperature, humidity, and plant nutrition were all measured (ppm). The research phase also includes the creation of hydroponic growing instruments (Figs. 1 and 2).

Installation of hydroponic displays (cultivation sites) for plants is carried out in the laboratory on the 18th floor of Unikom. Figure 1 depicts the steps taken. Mild steel is arranged as a hydroponic frame according to a predetermined design, and then a pipe is installed as a place for planting seed pots.

Fig. 1. Hydroponic display installation.

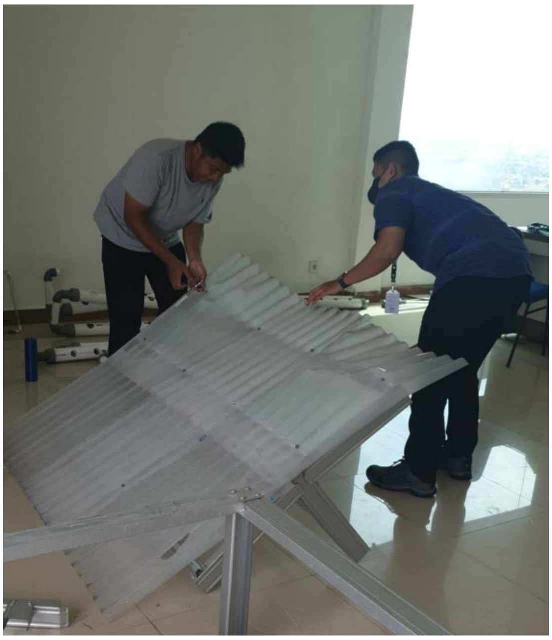

Fig. 2. UV plastic roof installation.

Figure 2 shows a plastic roof being used as the roofing material for the hydroponic display. The percentage of UV was 14%, which indicates the number of chemical additives contained. UV plastic is used to filter light and other harm as the number of compounds increases. The advantages of the UVplastic roof used are UV IR (infrared) + AB (antibacterial) + EVA (Ethylene Vinyl Acetate) + LD (Light Diffuser) with LDPE Raw Material.

4. Results and Discussion

4.1. Hydroponic system

Deep Flow Technique (DFT) systems are used in hydroponic gardening. The nutrient solution is supplied to the plants in the DFT system whenever the water level in the farm falls below a set value, and it is recirculated and supplied to the plant roots at constant time intervals in a farm with a slope of 1/100 [24]. The nutrient solution that is not absorbed by the plant returns to the nutrient tank in a recirculation system. As a result, evaluating the loss of nutrient solution in the tank may simply quantify the uptake of water and nutrients by plants. Figure 3 is a model of the hydroponic system that was used in this research.

Fig. 3. Indoor hydroponic design.

Plant contamination by pathogens is lower in hydroponic cultivation than in soil cultivation. However, when one plant is affected, the disease can quickly spread to nearby plants via nutritional solutions. UV radiation can protect plants from disease by disinfecting them [24]. UV light has the ability to kill bacteria, viruses, and protozoa without changing the chemical composition of water. UV radiation can cause cell death and mutations when it is absorbed by proteins, Ribonucleic Acid (RNA), and Deoxyribonucleic Acid (DNA) [25]. UV light that can kill bacteria has a wavelength of 220-290 nanometres, with 253.7 nanometres being the most effective [26]. The ratio of disinfection to pathogens is linked to light intensity and time of exposure to UV radiation [24].

4.2. Plant seed cultivation stage

The seeding phase is the first stage in hydroponic plant production. Cutting Rockwool to the size of 1 tiny glass container, then inserting it in a container with plant seeds, using a toothpick to make it easier to plant into Rockwool, is the first step in the seeding phase. The seeding period is 10–14 days long. Following that comes the planting stage, which begins after the 21-26 days mark. The ppm content and pH of the water are checked every two days to ensure proper nourishment. The standard ppm range is 560–1400 ppm, with a pH range of 6,5–9. After the plant has reached the age of 30 days, the harvesting begins.

4.3. Plant nutrient content

The study was conducted for 30 days starting after seed-planting period, which was 14 days prior. Throughout the planting phase, daily monitoring is carried out to ensure that the nutrient content of the water is stable and meets the minimum and maximum limits. For the nutrient content of the water, it must be within 560-1400 ppm [27]. While the level of acidity of the pH of the water that is good for vegetable plants ranges from 6.5-9 [27]. Table 1 shows the nutrient content, degree of acidity (pH), air temperature, and humidity measured for 30 days from planting to harvest. UV LED rays contribute some of these content factors that influence plant growth and give light source stability to support plant photosynthesis [28]. The nutritional content tends to be low on the first day of measurement with a value of 678 ppm. The following day, though, it proceeded to steadily rise to 1310 ppm. Nutrient levels tend to stay steady >1200 ppm for up to five days. The nutritional content was evaluated for 30 days to see if it fluctuated, but it remained consistent within the permissible range. The maximum nutrient concentration was at 1700 ppm on day 24 and the lowest was at 234 ppm on day 13.

Table 1. Nutrient content, pH, temperature, and humidity.

Day After Plant	Date	pH Value	Nutrient Solution Level (ppm)	Temperature (°C)	Humidity (%)
Day 1	27/09/2021	6.71	678	28.20	75
Day 2	28/09/2021	6.07	1310	29.30	59
Day 3	29/09/2021	6.50	1260	26.90	74
Day 4	30/09/2021	6.60	1210	28.70	69
Day 5	01/10/2021	6.47	1310	27.00	58
Day 6	02/10/2021	6.33	1290	29.80	56
Day 7	03/10/2021	6.60	710	26.80	66
Day 8	04/10/2021	6.60	710	26.80	66
Day 9	05/10/2021	6.86	671	27.70	66
Day 10	06/10/2021	6.86	671	27.70	66
Day 11	07/10/2021	7.70	703	28.50	66
Day 12	08/10/2021	7.70	703	28.50	64
Day 13	09/10/2021	7.40	234	28.20	72
Day 14	10/10/2021	7.80	1400	29.30	68
Day 15	11/10/2021	6.50	1410	26.90	55
Day 16	12/10/2021	6.79	1390	28.70	59
Day 17	13/10/2021	6.79	1390	26.70	59
Day 18	14/10/2021	6.82	1332	30.40	74
Day 19	15/10/2021	7.75	1300	27.70	69
Day 20	16/10/2021	7.70	1260	31.00	58
Day 21	17/10/2021	7.88	1360	28.90	56
Day 22	18/10/2021	7.30	1570	26.90	66
Day 23	19/10/2021	7.16	1640	27.10	66
Day 24	20/10/2021	7.11	1700	25.40	84
Day 25	21/10/2021	6.80	1400	28.90	61
Day 26	22/10/2021	6.43	1600	25.90	71
Day 27	23/10/2021	6.58	1340	26.30	77
Day 28	24/10/2021	6.90	1450	27.10	80
Day 29	25/10/2021	7.05	1135	28.30	68
Day 30	26/10/2021	6.73	1240	26.50	76

At normal pH levels, the acidity content of the water as a whole is highly safe, with a minimum of 6.07 on the 2nd day and a maximum of 7.88 on the 21st day. The pH of water has a huge impact on plant growth; if it is not steady, it can reduce plant height by a small number of leaves [29]. Temperature, in addition to the degree of acidity and pH, is a characteristic that must be considered throughout the planting process. In Indonesia, a good water temperature is between 20 and 32 ° Celsius [30]. During the planting period, the water temperature is extremely safe, ranging between 25 and 32 degrees Celsius. The lowest temperature was 24.4° C on day 24 and the maximum temperature was 31° C on day 20. As a result, it may be stated that the water temperature supports optimal plant growth.

4.3.1. Plant growth

Plant growth was observed every day for 30 days by measuring from the base of the stem and roots to the tip of the highest leaf. The development of plant height is shown in Fig. 4.

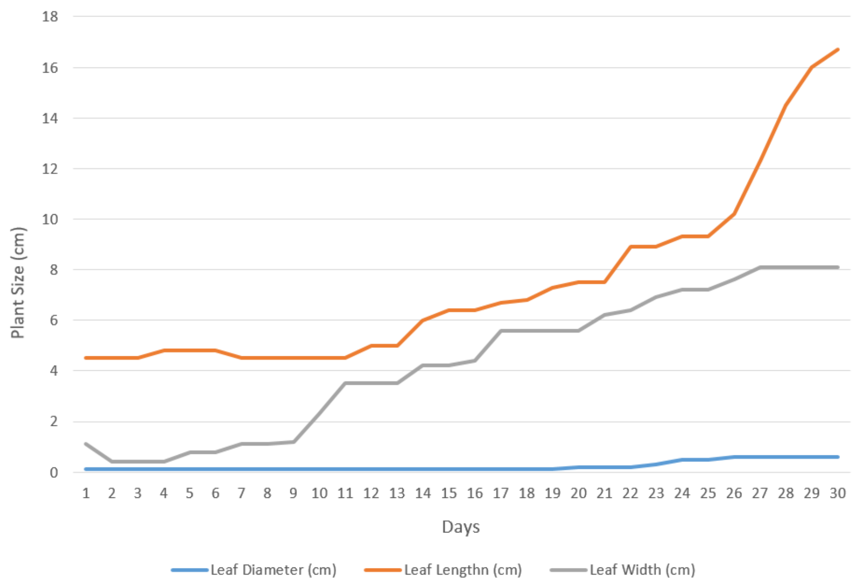

Fig. 4. Indoor lettuce plant height chart.

Figure 4 depicts the growth of lettuce plants in a room utilizing UV irradiation and progressive nourishment from seeding to harvesting in 30 days. The biggest size of the leaf length is 4.5 cm and the width of the leaf is 1.1 cm in the first week. The size of the plant did not change until the 11th day. By the second week, the leaf width had increased to 4.2 cm and the leaf length had increased to 6 cm. The plants grew normally after entering the third week, up to 1-2 cm from the previous week. The plant grew significantly in week 4 with the longest leaf length reaching 16.7 cm, the widest leaf breadth 8.1 cm, and the smallest leaf diameter 0.6 cm. Based on these findings, it was determined that plants treated with UV radiation indoors could have an impact on their growth rate and size. UV rays replace the role of sunlight, so even though they are in a closed room, plants can still carry out photosynthesis. Plant photosynthesis can be increased by using regular light sources [31]. Increasing the rate of photosynthesis will result in a huge amount of carbohydrates being produced. Carbohydrates are the basic components for protein synthesis and other substances that help plants grow organs and carry out their functions. Hydroponic plants exposed to UV radiation demonstrated greater growth and quality than traditional cultivation approaches, as measured by leaf length, leaf breadth, and stem diameter. This is because UV radiation has the capability to increase plant development. Plants that can carry out more photosynthesis produce more photosynthate, causing their weight and size to increase in comparison to other plants [32]. The situation is considered to be in a state of conspicuous consumption if the plant tissue contains specific nutrients in concentrations greater than those necessary for maximum development [33]. UV radiation with the right and consistent wavelength kills microorganisms that cause problems for plants without harming the plants [31].

4.4. Crop harvest condition

In the testing process, the plants used were bok choy, kale and lettuce, where each plant received the same treatment. For the bok choy plants, the 40 seeds were planted and 38 of them grew. In water spinach plants, the number planted was 20 and all the plants grew, indicating that the treatment received was very suitable for these plants. In lettuce, the number planted was 20, and 18 of them grew. Although neither bok choy nor lettuce had a growth percentage as high as water spinach, they were still in the good category, with growth percentages of more than 90 percent (Table 2).

Table 2. Crop yield condition.

Plant Type	Amount Planted	Plants Growing Number	Percentage
Bok choy	40	38	95%
Kale	20	20	100%
Lettuce	20	18	90%

Plant growth, particularly lettuce, is in a good category with diverse plant diameters as illustrated in Fig. 3. Crops may be harvested in 30–35 days with a reliable irrigation system and UV light, which is 30–50% faster than the standard 45 days. Each plant stem can weigh between 200 and 500 grams. This is related to the constant monitoring of nutrient doses to ensure that they comply with the requirements of the plant. These findings are consistent with Rizal's findings, which show that providing liquid nutrients in an amount that corresponds to plant demands promotes optimum plant growth [30]. Cell division, enlargement, and elongation are accelerated by proper nutrition, resulting in faster cell division, enlargement, and elongation.

The yields of several types of hydroponic plants have a better appearance because of maximum growth; they look cleaner and fresher, and the leaves are brighter. Without using soil, the hydroponic system eliminates the need for extra effort to clean the crops, and the vegetables are free from insects and animals.

In addition to producing quality plants, the advantage of hydroponic cultivation is that the operational costs of plant production, such as the use of liquid fertilizers (nutrients) and water, can be streamlined. In hydroponics, the number of nutrients can be controlled according to the needs of the plant, so nutrients are not wasted.

The nutrients provided will continue to be in the water reservoir pipe container without being wasted in the environment.

5. Conclusion

Based on the results of observations of plant growth for 30 days, it shows that plants developed using hydroponics indoors with the help of UV light experience maximum growth and are 30% - 50% faster than traditional cultivation techniques. With a measure of the nutritional content in stable water in the range of 560-1400 ppm, and the level of acidity of the pH of the water in the range of 6,5-9. From these results, the average plant size after harvest was 0.6 cm stem diameter, leaf length 16,7 cm, and leaf width 8,1 cm. These yields can be obtained because hydroponics emphasizes the fulfilment of nutrients that are continuously controlled for plants and the adequacy of the need for UV rays that can maintain the quality of hydroponics by the needs of plants at once. UV light helps meet the photosynthetic needs of plants and causes more photosynthate to be formed so that the weight and size of the plant become larger. Radiation from UV with the right and regular wavelength will kill the annoying bacteria without harming the plant itself.

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