International Journal of Research Studies in Educational Technology
2024 Volume 8 Number 3, 99-106

LED light greenhouse with automatic water dispenser using Arduino Uno for indoor plants

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ISSN: 2243-7738
Online ISSN: 2243-7746

OPEN ACCESS

Received: 10 May 2024 **Revised**: 27 June 2024 **Accepted**: 3 July 2024
Available Online: 15 July 2024 **DOI**: 10.5861/ijrset.2024.8026

Abstract

Many people experience the death of their plants due to insufficient sunlight or water. The researchers developed an LED light greenhouse with an automatic water dispenser using Arduino Uno to help those who struggle to care for their plants or are overly busy with their schedules. The device automatically waters the plant when it detects a lack of moisture in the soil. LED lights serve as a substitute for the plants to grow to their total capacity if there is a lack of sunlight. Data was collected from 20 students who tested the product using an evaluation checklist. The participants strongly agreed that the device is effective in dispensing water and detecting the soil's moisture level. The observed delay in water dispensing, ranging from 0.2 to 0.3 seconds, suggests a consistent response time once operational. This reliability is essential for maintaining optimal soil moisture levels, promoting plant growth, and minimizing fluctuations that could negatively impact plant health. During the ten days of observing and measuring the height of the Sili Labuyo plant, the researchers observed a noticeable increase in height. The plant started with a height of 2.2 inches and ended with a height of 2.8 inches. The LED light greenhouse with an automatic water dispenser utilizing Arduino Uno for indoor plants successfully enhances plant growth and ensures plant life. This study recommends choosing lights with high energy efficiency. Proper light is essential for plant growth.

Keywords: automatic water dispenser, LED light, Arduino Uno, greenhouse, sili labuyo

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1. Introduction

Water is one of the necessary components a person needs to survive. It helps regulate body temperature. Just like humans, plants need as much water as everyone. Conserving water is essential since it is in such high demand and is used by everybody. The bringing of plants indoors can take a toll on its growth. They do not receive the vital nutrients from sunlight, which hinders or delays the plants' ability to grow to their full potential. It is anticipated that a lighting system will be created that utilizes the distinct properties of an LED as a point light source or thin-line light source. Moreover, Dănilă and Lucache (2016) state that the optimum spectrum of light wavelengths is necessary for healthy plant growth. Based on the LED Spectra dedicated software, the paper analyzes a standard LED grow lighting module for two species of plants. The greenhouse serves as a refuge for plants. It lessens the likelihood that pests and animals will be present that could harm or devour your plants (Arif & Abbas, 2015). This shortcoming is primarily attributable to the complexity of the estimation process and the requirement to consider several essential parameters. The most well-liked agricultural sector nowadays is the greenhouse, which enables farmers to segregate crops from the farm so that each can have its habitat. Farmers can modify the environmental conditions in a greenhouse to meet the needs of the crops, which is an advantage.

Many people are having trouble taking care of their plants; many suffer from the death of their plants when the weather is hot. Some plants cannot fully reach their potential growth without sunlight (Kalabkin et al., 2023). This research study is for people who need help taking care of their plants or are busy with their schedule so that plants can reach their potential growth by substituting sunlight with LED lights if sunlight is unavailable. Taking care of plants is extremely difficult for those with a busy schedule. The researchers have experienced that caring for plants requires time and energy. They have witnessed family members spend hours watering and caring for the plants and the soil. To care for a plant, one must sacrifice both time and energy. It is remarkable to cultivate so many plants, especially for someone with a busy schedule. Many individuals struggle to maintain their plants 'health. This is why the researchers are developing this study: to help people who have trouble taking care of their plants due to weather changes or are busy with their schedules. So their plants can get sunlight through the LED and get the water they need when you are away. LED lights can be used as a substitute for sunlight and automatic water dispensers so that the water will enhance/upgrade the quality and growth of the plants. Not only would this project protect it from the strong winds, but it would also prevent the plants from drowning because of the rain. Technology is the new trend nowadays and has found a way to benefit our daily tasks. Using the Arduino UNO enables the activation of an LED light greenhouse as an automatic water dispenser.

This study aimed to develop an LED light greenhouse with an automatic water dispenser using Arduino UNO. In addition, it intends to enable you to grow a wide range of indoor plants in any environment and at any time of year. Sunlight is optimum for plant growth; however, artificial lighting can enhance the quality of light that plants get while also enhancing plant development. It has an automatic water dispenser programmed to sense plants' moisture levels. Hence, the users can water their plants automatically at the proper intervals and with the appropriate volume of water. The study provides convenience in caring for plants, specifically for caretakers or gardeners. It serves as a device to ease the work of the individuals in charge of this work in every household, especially for those who multitask. This study aimed to test the use of LED light to improve the quality of the plant (Sili Labuyo) and for faster reproduction during the rainy season for indoor plants. It also aims to automatically dispense water when dry soil is dry, promoting a hassle-free, time-saving atmosphere.

Statement of the Problem - This study aimed to develop an LED light greenhouse with an automatic water dispenser using Arduino Uno. Specifically, it sought to answer the following questions: (1) What is the level of effectiveness of the LED Light Greenhouse with Automatic Water Dispenser using Arduino Uno in terms of the

amount of water dispensed and the moisture level of the soil? (2) What is the length of the delay in the amount of water dispensed once the soil moisture alarms its system? (3) Is the soil moisture sensor effective in alarming the device when the plant starts to experience the effects caused by a lack of moisture? (4) Is the LED Light Greenhouse Automatic Water Dispenser using Arduino Uno efficient in terms of plant height? (5) Is there a significant difference between LED lights and natural sunlight in terms of plant growth?

Significance of the Study - The creation of the LED Light Greenhouse aimed to improve the quality of the plant by pointing the LED light inside the plant in a clear container. With the light's heat, the soil's moisture was detected, and water was automatically dispensed, promoting a hassle-free and time-saving atmosphere. The invention was efficient at watering plants without any effort. It can immediately do its job simply by sensing heat to a specific extent. The results and findings benefit the following: for the staff of the DWCSJ, it would help a lot considering how much they multitask to tend to the things that their job requires them to accomplish. For the DWCSJ students aspiring to become agriculturists, different data and findings can be taken from changing the variables. For the Mangyan Education Center, this will help Mangyan scholars in their area because their plants do not get enough sunlight during the rainy season. For nature enthusiasts, it wouldn't feel like a task but more of a hobby they would enjoy, as it wouldn't require much effort. For individuals in households, it would be a lot of help considering the amount of household chores an individual must accomplish to sustain their homes. It would be to lessen even one of those works for them. For future researchers, it would serve as a lesson regarding the importance of this kind of invention to the mentioned problems. It can also motivate them to innovate and prevent the risk of negligence for our plants.

Scope and Delimitation of the Study - The general intent of this study is to develop an LED light greenhouse with a water dispenser using an Arduino Uno. This study determines the effectiveness of the proposed project. This machine is a great help in the summer and rainy seasons. This research project titled "LED Light Greenhouse with Automatic Water Dispenser using Arduino Uno" uses LEDlights as a substitute for sunlight. With LED lights, the plant's potential growth is reached, and you don't need to water the plants since it has a water dispenser manually. The study focuses on developing a prototype of an LED light greenhouse with water dispensers; this product can be used indoors or outdoors. This research study only used Arduino Uno to build the prototype. This study does not cover the maintenance of LED lights as it will only focus on the effectiveness of LED lights if sunlight isn't available due to the rainy season.

2. Methodology

Research Design - This study employed an experimental design to develop an LED light greenhouse with an automatic water dispenser using an Arduino Uno for indoor plants. Experimental study design is a technique for demonstrating a cause-and-effect link between two or more variables and/or materials. Various tests were performed to determine the efficacy of LED lights in the growth of plants as a substitute for sunlight. With the help of the Arduino Uno, we can create this project. Thus, this aimed to reach plants' total growth and protect them from their harmful environment. To protect plants from parasites and strong winds and prevent the plants from drowning because of overwatering. The night also does not hold back the growth of the plants because of the LED lights. It has an automatic water dispenser to save time for the owners and prevent overwatering the plants.

Data Gathering Procedure - The researchers used the Sili Labuyo as their indoor plant. They observed the plant inside the transparent container for 10 days. After watching, they assessed whether the plant had grown better or whether water was still being released into the soil when it got dry. Subsequently, the quality of the plants illuminated by LED lights and those exposed to sunshine was compared. The researchers recorded their observations and compared the plant data.

Research Process: Stage 1 Preparation and Gathering of Materials - The following materials are needed to produce an LED light greenhouse with an automatic water dispenser.:

- For the LED light greenhouse: LED Lights, recycled plastic bottle, and battery.

- For the automatic water dispenser: Arduino UNO, jumper wires, Hose, battery, 5-volt relay module, soil moisture sensor, and submersible small water pump

The researchers used recycled materials to make it affordable and sustainable. The researchers purchased materials online and from local stores. The total cost of these items is around P1450.

Stage 2: Building and Development of the Project - To create an LED greenhouse, it is first necessary to cut a plastic bottle in half, then add some holes to serve as ventilation and the LED lights. To prepare the water dispenser, the researchers must connect the moisture sensors and the control board of the Arduino. The next step is to connect the relay module and the water pump to the Arduino. After that, the researchers proceeded to code. The researchers took two days to build and code the device. The device and the Arduino Uno are placed near the plant once the water dispenser is finished. The water bottle absorbs the heat throughout the day and warms the plant and the air inside. The LED lights substitute for sunlight when the weather is gloomy or dark. The Arduino UNO and the water dispenser water the plant when the soil is dry.

Figure 1. Actual Product of an LED light greenhouse with an automatic water dispenser using Arduino Uno for indoor plants

Stage 3: Experimental Stage, Observation and Data Recording - The researchers executed the experimentation for the final product using Sili Labuyo as an indoor plant: From March 20 - April 10, the researchers coded and assembled the Arduino Uno and the moisture sensor. The researchers used a clear plastic bottle as the greenhouse and created multiple small holes at the top and bottom of the bottle. The bottle is placed on top of the soil, and the LED light is placed inside the bottle. The researchers prepared a water tank that was not intact with the bottle. The hose is placed through one of the small holes at the top of the bottle. From April 10 - April 23, the researchers measured the plant growth from the soil to its highest point every week. The researchers gathered data through first-hand observations, testing, and experimentation. The researchers thoroughly investigated the device to confirm that the data gathered and acquired is practical, applicable, and valuable. The researchers recorded statistical data on the devices' capacity and limitations, utilizing the given documents and data testing and procedures with multiple strategies. The findings and gathered data are then recorded from the study's testing. The evaluation checklist that the researchers used to determine the device's effectiveness was validated using expert and face validity. The comments and suggestions were followed for the final copy of the evaluation checklist.

Statistical Treatment of the Data - In executing this study, the researchers used statistical analysis, mainly the weighted mean, to determine the effectiveness of the LED light greenhouse with an automatic water dispenser using Arduino Uno. In addition, a T-test was used to determine the significant difference between the LED light greenhouse with an automatic water dispenser using the Arduino Uno and the effects of natural sunlight and manual water. Evidence, which aims to support the interpretations, was showcased through the use of tables and graphs; it provides justifications on how it resulted in the claim that the LED light greenhouse with an automatic water dispenser using Arduino Uno is as effective as natural sunlight and less time consuming than manual

watering.

3. Results and Discussions

Table 1

Mean Level of the effectiveness of the LED Light Greenhouse with Automatic Water Dispensing Arduino Uno in terms of Detecting the Moisture Level and Water Dispensed

Indicators	Weighted Mean	Descriptive Indicator
1. The device is effective in detecting the moisture level.	3.40	Strongly Agree
2. The device is effective in dispensing water.	3.48	Strongly Agree
Overall Mean	3.29	Strongly Agree

Legend: 3.26 - 4.00 Strongly Agree, 2.51 - 3.25 Agree, 1.76 - 2.50 Disagree, 1.00 - 1.75 Strongly Disagree

The experiment outcomes, as indicated by the participant feedback, are presented in the table above. Table 1 shows the effectiveness of the moisture sensor and the water dispenser. Researchers closely monitored the device's capacity to identify low moisture levels, observing its ability to generate adequate water to restore moisture levels to their natural state. This proved that the LED Light Greenhouse effectively detects moisture levels and water dispensed. The findings were supported by Liu et al.'s (2024) finding that for the vegetation state and associated land-atmosphere coupling, critical soil moisture (CSM), a tipping point of soil moisture (SM) when evapotranspiration (ET) starts to suffer from water limitation, is crucial.

Table 2

Length of the delay of the amount of water dispensed once the Soil Moisture alarms its system

TRIALS	Length of the time	Water Dispensed (Working or not Working)
1	0.3 sec	1
2	n/a	0
3	0.2 sec	1
4	0.3 sec	1
5	0.3 sec	1

Legend: 1-working, 0-not working

Five trials were conducted to determine how long the water delivery delay is after the soil moisture warning system sounds. The water poured into the first experiment is functioning, as evidenced by the duration of 0.3 seconds. The researchers didn't track the delay because the second trial didn't due to issues with the motor's wiring; thus, it is not applicable. It worked on the third try, with a 0.2-second delay. The fifth experiment likewise saw a 0.3 delay, as did the fourth. According to Boateng and Koenig (2007), efficient soil moisture monitoring of irrigated fields can reduce irrigation costs and preserve necessary resources. This can be accomplished by tracking soil moisture levels with devices like tensiometers and neutron probes (Yu et al., 2021).

Table 3

Correlation Analysis on the Effectiveness of Soil Moisture Sensor in alarming the device at the exact moment the plant starts to experience the effects caused by lack of moisture

Independent Variable	Dependent Variable	R-value	R^2 (Effect Size)	t-value	P value	Interpretation
LED Light Greenhouse	Alarming the Device	0.556713	0.309929	2.3228	0.048706	Significant

Legend: *Highly Significant at p≤0.01 *Significant at p≤0.05

Table 3 shows the correlation analysis on the effectiveness of the soil moisture sensor, which alarms the device when the plant starts to experience the effects caused by a lack of moisture. The R-value of 0.556713 and P-value of 0.048706 show that the soil moisture sensor is effective in alarming the device when the plant starts to experience the effects caused by a lack of moisture. This experimental study proved that LED light greenhouses effectively alarm the device. According to Raikar et al. (2024), to determine the current soil moisture content, which manages and controls the water supply for irrigation, smart irrigation systems are crucial. To facilitate the release of irrigation water, the current study focuses on the on-board installation of a soil moisture sensor with an Arduino UNO platform to measure the moisture content of soil samples.

Table 4

Correlation Analysis on the Efficiency of LED Light Greenhouse Automatic Water Dispenser using Arduino Uno in terms of Changes in the Height of the Plant

Independent Variable	Dependent Variable	R-value	R^2 (Effect Size)	t-value	P value	Interpretation
LED Light Greenhouse	Height of the Plant (Sili-Labuyo)	0.91279	0.833186	6.3190	0.000228	Highly Significant

Legend: *Highly Significant at p≤0.01 *Significant at p≤0.05

The researchers observed the Sili Labuyo (the indoor plant used) for ten days. From day one, the height of the plant was 2.2 inches, growing to 2.8 inches by day 10, and the plant grew 0.1 inches. This data proves that LED lights in greenhouse automatic water dispensers have a significant effect on the growth of plants. Table 4 shows the correlation analysis of the efficiency of an LED light greenhouse automatic water dispenser using Arduino Uno in terms of changes in the height of the plant. Considering the variables in the table above, it shows that the LED Light Greenhouse Automatic Water Dispenser using Arduino significantly affects the height of plants. According to Kalabkin et al. (2023), in their study, the grow light's photosynthetic efficiency was 1.84 μmol/J. Therefore, this growth light can efficiently cultivate crops in greenhouses, offering ideal lighting conditions and enhancing crop quality and yield.

As observed by the researchers for ten days. From day one, the height of Sili Labuyo was 2.2 inches, growing to 2.8 inches by day 10, and the plant grew 0.1 inches. According to Hadj-Abdelkader et al. (2023), LEDs are proven to be the best artificial light source used in indoor agriculture. LEDs are a sustainable and effective source of artificial light that is continuously gaining ground in indoor farming. Moreover, the information presented above is the t-test results, which show the difference between LED lights and natural sunlight regarding plant growth. As shown in the table above, the t-stat value, 10.5011, is greater than the critical value of 2.2281. This procedure results in rejecting a null hypothesis, which means there is no significant difference between LED lights and natural sunlight regarding plant growth. This means that LED lights and sunlight effectively improve plant growth, according to Kalabkin et al. (2023). Findings proved that white LED light intensity and 20 hours of irradiation time outperformed other treatments regarding plant height, root weight,

fresh weight, leaf length, leaf width, number of leaves, and water efficiency.

Table 5

t-Test Results: Difference between LED Lights and Natural Sunlight in terms of Plant Growth

	Variable 1	Variable 2
Mean	2.544444444	0.666666667
Variance	0.037777778	0.25
Observations	9	9
Hypothesized Mean Difference	0	
df	10	
t Stat	10.50114905	
P(T<=t) one-tail	5.06789E-07	
t Critical one-tail	1.812461123	
P(T<=t) two-tail	1.01358E-06	
T Critical two-tail	2.228138852	

Legend: *Highly Significant at p≤0.01 *Significant at p≤0.05

4. Conclusions

The following conclusions were drawn based on the study's findings: the moisture warning system displayed varying performance across multiple tests, and consistent functionality was observed in subsequent trials despite initial wiring issues. This indicates the system's resilience and adaptability, which are crucial for reliable operation in real-world scenarios. The observed delay in water dispensing, ranging from 0.2 to 0.3 seconds, suggests a consistent response time once operational. This reliability is essential for maintaining optimal soil moisture levels, promoting plant growth, and minimizing fluctuations that could negatively impact plant health. The Automatic Water Dispenser effectively contributed to the growth of Sili Labuyo plants over ten days, with a noticeable increase in height from 2.2 to 2.8 inches. This growth trend and the water dispenser's consistent operation underscore its role in facilitating plant development and supporting overall plant health. The Soil moisture sensor demonstrated functionality and reliability throughout the testing phase, highlighting its potential as a valuable tool for researchers and farmers. Its ability to accurately monitor soil moisture levels enhances precision in irrigation practices, optimizing water usage and promoting sustainable agriculture. The successful operation of the alarming device and its associated functions further validate the effectiveness of the integrated system in monitoring and managing environmental conditions for plant growth. This comprehensive approach offers a promising solution for enhancing agricultural productivity while minimizing resource waste, contributing to advancing innovative farming technologies.

Recommendation - The study's conclusions and outcome led the researchers to recommend the following: The researchers discovered that wiring and coding play important roles in devices. If a device is effective, its significant effect can affect even a minor coding. The moisture sensor may use the wires and codes correctly to ensure the water is just right for the plant. The researchers recommend that the farmers use battery sensors to see if the battery is running low and to prevent the plant from accidentally dying. Famers may use lights with high energy efficiency. Proper light is very important for plant growth. The researchers recommend having a backup power source for greenhouses because they depend on automated systems. Consider getting a battery backup system to ensure your plants survive power outages. The researchers recommend against placing the light too close to the plants to prevent burning. The user may use the correct type of light when arranging the different lights on the plants. The researchers advise future researchers who wish to conduct more research to speak with colleagues or subject matter experts who have conducted related experiments.

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