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IOT Integration in Water Absorption of Sprout Growth System

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ABSTRACT

This research addresses the limitations of conventional mung bean sprout production methods by introducing an innovative, automated system. As small-scale sprout maker, current machine has non-stop watering, proves inefficient in regulating water and adversely affecting sprout growth. To counteract these shortcomings, the study presents an upgraded machine integrated IoT and systematic watering schedule. These setups involve varied mung bean quantities tested in sealed containers with controlled germination conditions. Over a two days period, the upgraded system demonstrates a comparable improvement in mung bean sprout growth parameters, evidenced by mung bean sprout growth and water absorption applying program watering system. Integrating the Internet of Things (IoT) through the Blynk platform facilitates real-time data analysis, adding dynamic understandings into environmental conditions. In conclusion, this study highlights the upgraded system's execution, providing superior yield across various weight categories and emphasizing the role of advanced technology in optimizing agricultural machinery. The findings contribute substantively to discussions on technological enhancements emphasizing on the potential for water usage efficiency.

1. Introduction

Technological advancements have revolutionized various sectors and agriculture is no exception. One remarkable innovation in recent years is the automated mung bean sprout plant system, which aims to enhance plant growth parameters. This system integrates automation and plant science to optimize the growth and development of mung bean sprout plants, leading to improved crop yields and quality.

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Kariyasa *et al.,* [1] conducted a study on mung beans in 2011 [2]. They found that mung beans are a type of legume member of the Fabaceae family, referred as a green gramme or moong. Mung bean sprout production is estimated to reach 5.3 million tonnes per year, with most of the world's supply coming from China, Myanmar, India, the United States of America, Canada and Brazil, respectively. The conventional method of cultivating mung beans, often involves soaking them in non-circulating water and in enclosed container, might result in the mung bean sprouts sold in local markets having an unpleasant odour. It is essential to provide adequate moisture during the cultivation process; failing to do so will result in mung bean sprouts that have developed mould and emit an unpleasant odour, while failing to provide sufficient moisture will result in too thin sprouts [3]. The soilless automatic cultivation of beans sprout which can monitor online adopted closed bin structure and the temperature and humidity sensor being applied [4].

In related to watering, according to El-Nakhlawy *et al.,* [5], the daily water supply increased throughout the growing seasons until the plants achieved their maximum size, which then was reduced. The reduction in yield and yield components was more severe when water stress was applied during the flowering stage than when full irrigation was used.

Meanwhile, Hatfield *et al.,* [6] found greater temperatures cause all the biological processes that occur in plants to speed up. The growth stage that a plant is in will determine how sensitive it is to the temperature of its surrounding environment. The temperature of the plant's body and the surrounding air are two variables that the plant constantly monitors and attempts to keep in equilibrium. If the plant is heated up, the transpiration rate will increase to cool the plant down. This will also increase the amount of water and nutrients the plant will take in, resulting in phonological changes in the plant. During the initial stages of development, this assimilation process happens quite quickly [7]. Other researcher assessed mung bean sprout temperature between 10 to 30°C and found that at temperature treatment 30°C produced the highest of average output (58.96g) overall [8].

Other than that, increasing plant growth may be accomplished by keeping the air moisture level in the plant elevated (high humidity) as Chia *et al.,* [9]. Different relative humidity levels on kale plant growth in different cultivation periods [10]. In this study, increasing humidity level up to 85% increases the growth variables (weight and stem diameter) folded in 45% humidity level within two weeks of data collection. Humidity, temperature and light intensity becomes current development technology for managing greenhouse environments [11,12].

Overall parameters of watering, temperature and humidity affects the plant growth especially mung beans. However, this study limited to watering condition due to limited experiment conducted in ordinary environment.

1.1 Automated Agriculture System

Automated systems for plant growth, often called smart agriculture, are innovative technologies that leverage automation and advanced monitoring techniques to optimize and enhance the growth of plants. These systems combine various components such as sensors, actuators, data analytics and/or artificial intelligence to create a controlled environment for plants, representing or even greater optimal growing conditions found in nature. In other study, innovative system integrates precision agriculture and advanced technologies was suggested to restructuring farming processes for improved efficiency and productivity [13,14]. Choudhary *et al.,* [15] incorporated Arduino with tri-axial motor driver, soil moisture sensor, seed injector and a relay for device control.

A study had identified the agricultural Internet of Things (IoT) as a network physical entity, encompassing animals, plants, environmental factors, production tools and miscellaneous virtual entities [16]. The system established connectivity with the Internet through agricultural information perception equipment, adhering to specified protocols. This interconnected system facilitates the exchange and communication of information [17].

To enhance quality and quantity of agricultural product, Agricultural Internet of Things (Ag-IoT) is applied. This technology empowers the remote supervision and control of agricultural operations, allowing Ag-IoT to cater to the specific needs of plants and animals responsively. Notably, it contributes to the reduction of monitoring and labour costs. Acknowledged as a technological basis, Ag-IoT provides farmers and agribusinesses become into their ecosystems and facilitated a data-driven approach for various factors of agriculture, containing crop management, animal husbandry and supply chain logistics [18,19].

The project's aim is to develop a new upgraded sprout machine embedded with IoT monitoring. Firstly, developing a new watering system for the growth of mung bean sprouts is aimed at upgrading and adapting a machine currently available in the market. Secondly, the integration of the IoT into agricultural practices is planned, which will enhance connectivity and enable intelligent data monitoring. Lastly, determining growth of sprouts by investigating the water absorbed and weight of mung beans sprouts. Collectively, these objectives aim to revolutionize the cultivation of mung bean sprouts through development technology and advance monitoring.

2. Methodology

2.1 Upgraded Machine

To begin with, the current machine as in Figure 1 comprised of various integral parts; the water storage unit, plate, machine body and cover. Notably, the electrical components are situated beneath the water storage area, encompassing a water pump and circuit board within this designated section.

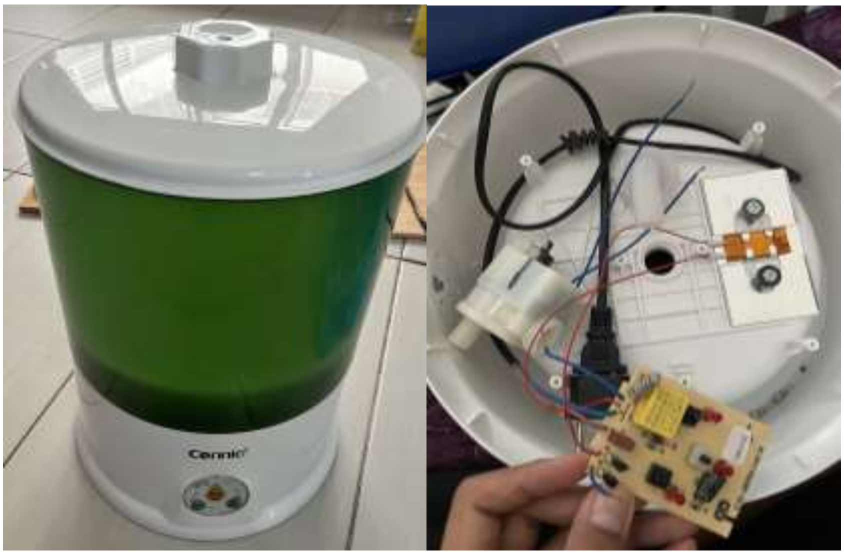


Fig. 1. Original body and electric circuit of current machine

It was observed that this current machine was operated at continuous watering circulation all the time without ability to monitor the environment temperature and humidity in enclosed space. Thus, the upgraded machine replaces electronic parts of circuit with Arduino, Wi-Fi module, relay, water pump, temperature and humidity sensor will be added. All components' functionalities are presented in Table 1.

Additional system set up to the upgraded machine results in Figure below. The Arduino Uno connected to the relay module and the relay module triggered a 12V input from it. The ground wire is connected to the Arduino Uno to complete the electric current. The signal wire is connected to PIN 2 on the Arduino Uno. AC 220V Water pump is connected to the relay module and power supply. The wire from the LIVE power supply is connected to the relay module and from the relay module, it is connected to the water pump.

Table 1
Additional electrical components of upgraded machine

	Arduino Uno • 14 digital input/output pins and six analogue input pins enable to connect with sensors of data acquisition. • Draw power from a computer via a USB or DC power supply
	ESP8266 Wi-Fi module • enables connectivity to Wi-Fi networks in embedded system. • A wireless platform uses for Internet of Things (IoT) applications • interface GPIO pins and a USB for programming
	Relay • Safe and efficient control of high-power circuits. • One channel module, maximum 5A output current • a reliable electrical power source for various electronic devices
	Water Pump • Uses 220AC volts to operate its motor • supplying water to residential buildings, irrigating fields and circulating water in industrial processes
	Temperature and Humidity Sensor • The DHT11 sensor measures ambient temperature and humidity levels
	Power Supply • AC-DC 12V 3A power supply converts alternating current (AC) electrical power from a wall outlet into stable 12-volt direct current (DC) power

Figure 2 shows the component system connection for Arduino and relay module circuit.

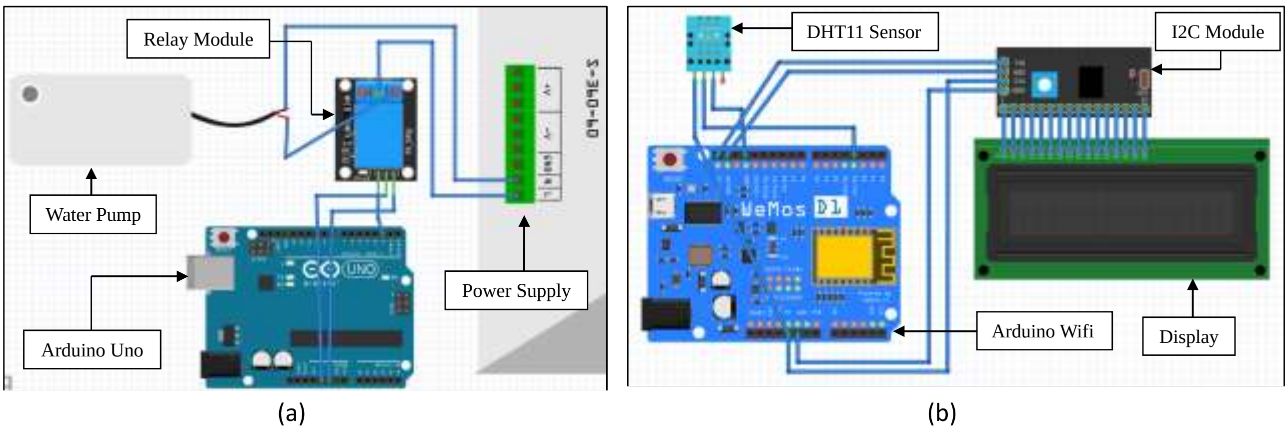
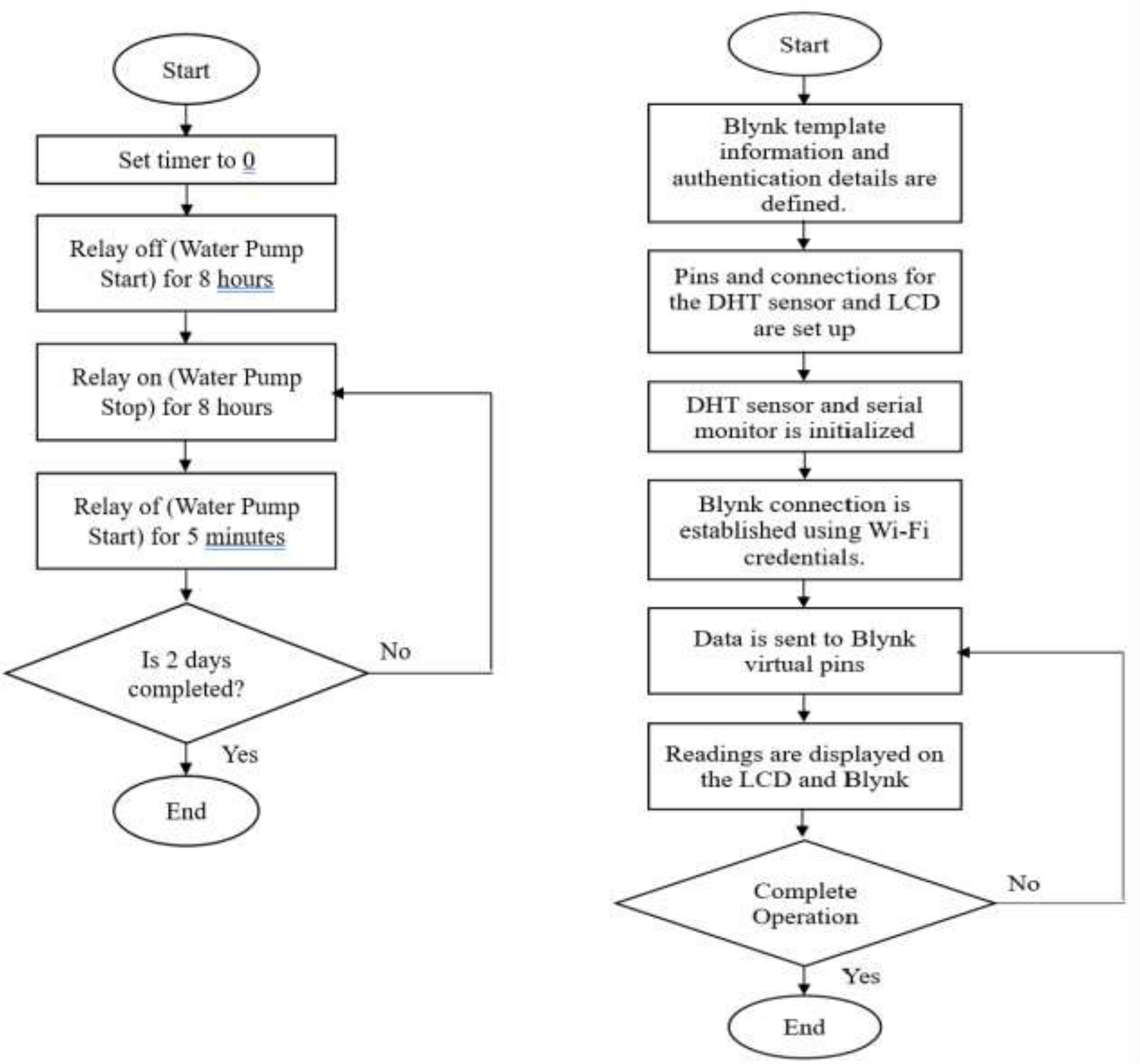


Fig. 2. Electronic system component connection diagram (a) Arduino Uno and relay module wiring for AC 220V water pump control (b) WeMos Wi-Fi integration with output display

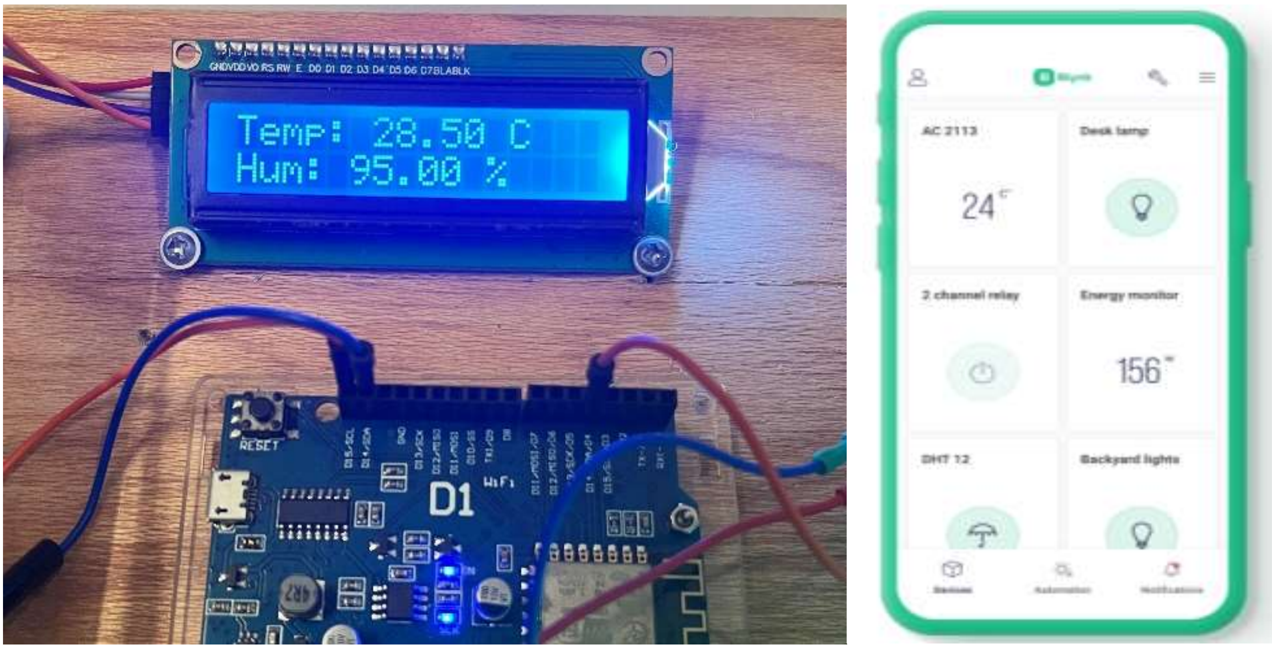
Next, Arduino Integrated Development Environment (IDE) is practised as structured program simplifying in Figure 3(a). This program is constructed for a sophisticated IoT initiative, focusing on the continuous monitoring of humidity and temperature data [20]. Finally, the Arduino facilitated through the Blynk platform allowing Wi-Fi module program.



(a) (b)

Fig. 3. Programming for (a) Arduino IDE (b) Arduino- Wi-Fi module

The experiment incorporated the DHT11 sensor to monitor humidity and temperature, aiming to understand the influence of environmental conditions on mung bean sprout growth. Figure 4(a). presents average humidity and temperature readings and illustrates real-time readings on an LCD, contributing to a comprehensive understanding of environmental parameters. The monitoring process supported by Blynk Apps interface *via* Wi-Fi connection (Figure 4(b)).



(a) (b)

Fig. 4. (a) Real-time humidity and temperature readings on LCD display (b) Blynk Apps interface

2.2 Experiment Design and Evaluation

Mung bean weight and its corresponding weight of mung bean sprouts are comparable increased between current and upgraded machines. This investigation examines the comparable result between current and upgraded machine operation towards yields of bean weight. Sprouts of varying weights were cultivated within the laboratory-scale setup. The growth and yield of the sprouts were monitored and recorded during the cultivation process. The performance of the sprout machine, including yield weight and the volume of water absorbed by sprout was evaluated and compared to manual watering methods. This experiment uses four selected weight samples 70g, 80g, 90g and 100g, with 1 litre of sprinkling water supply for both current and upgraded machine. Parameters and its range as depicted in Table 2.

Table 2
Parameters and its range

Parameter	Range
Machine	Current Upgraded
Weight of mung bean	50g -100g
Humidity	>80%
Temperature	ambient
Cultivated time, water amount	2 days 1 litre

The data collection for both current and upgraded machine are collected for sprout weight and water absorbed as calculated using Eq. (1) to Eq. (2) considerably.

$$\text{Weight of Mung Bean Sprout} = \text{Weight of Mung Bean Sprout with plate} - \text{Weight of Plate (46 grams)} \quad (1)$$

$$\text{Quantity of water absorbed} = \text{Quantity of Water Sprinkled} - \text{Remaining Water Balance} \quad (2)$$

Figure 5(a) shows set amount of mung bean firstly weigh is put in sieve, Figure 5(b) watering process when mung bean and final process of weighing to examine sprout weight gain.

(a) (b) (c)

Fig. 5. (a) Mung bean (b) Watering process (c) Weighing Mung bean sprout

3. Results and Discussion

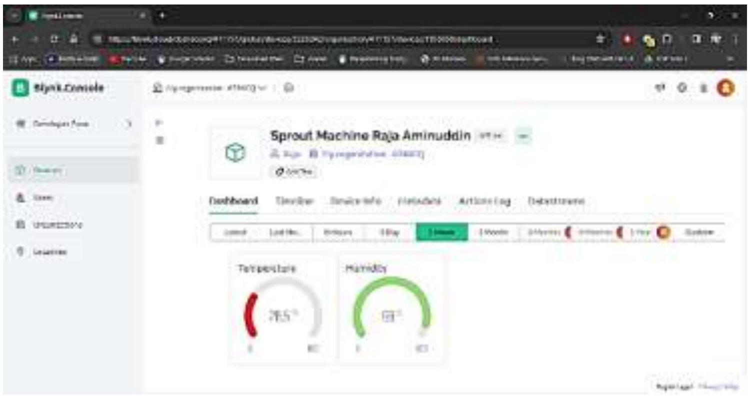
3.1 Upgraded Machine Integrated IoT System

Overall integration of these components is visualized in Figure 6. The overall setup of prototype presenting the upgraded sprout machine and system enhancement for optimal performance.

Fig. 6. Overall upgraded sprout machine prototype

The upgraded sprout machine followed a specific watering amount of 2 litres and the following frequency cycle for optimal growth. The watering cycle was initiated with 8 hours of continuous watering, followed by an 8-hour pause. Subsequently, the machine resumed watering for a duration of 5 minutes. This cycle continued for a span of two days. Temperature and humidity are monitored corresponding to its operation using Blynk interface which allows extensive distance IoT wireless communication. If any sudden condition is fails, then the setting of Blynk will notify the farmer to check the machine.

Blynk was integrated for real-time data analysis, allowing dynamic monitoring in humidity and temperature trends. Figure 7 shows real-time data visualization from Blynk, offering detailed of fluctuations in environmental conditions.



(a) (b)

Fig. 7. Blynk interface (a) Real-time data visualization from Blynk application (b) Real-time data visualization from Blynk website

3.2 Experiment Results

3.2.1 Sprout weight

Three setups with 70g, 80g, 90g and 100g mung bean weights were cultivated under controlled enclosed container conditions. Figure 8 presents weight comparisons, indicating the sprout growth in weight of the upgraded machine over the current machine. It was examined that, both current and upgraded machines show an upward trend in mung bean sprout weight, with slight dominant in the upgraded machine. This trend remains consistent across various weights (70, 80, 90 and 100g), with the upgraded machine consistently outperforming. The result shows increasing in mung bean weight will increase the sprout weight in both current and upgraded machine. However, the upgraded machine gives a slightly higher weight for sprouts. The straight line in Figure 8 shows the increment in difference of weight gain between sprout growth with current machine and upgraded machine.

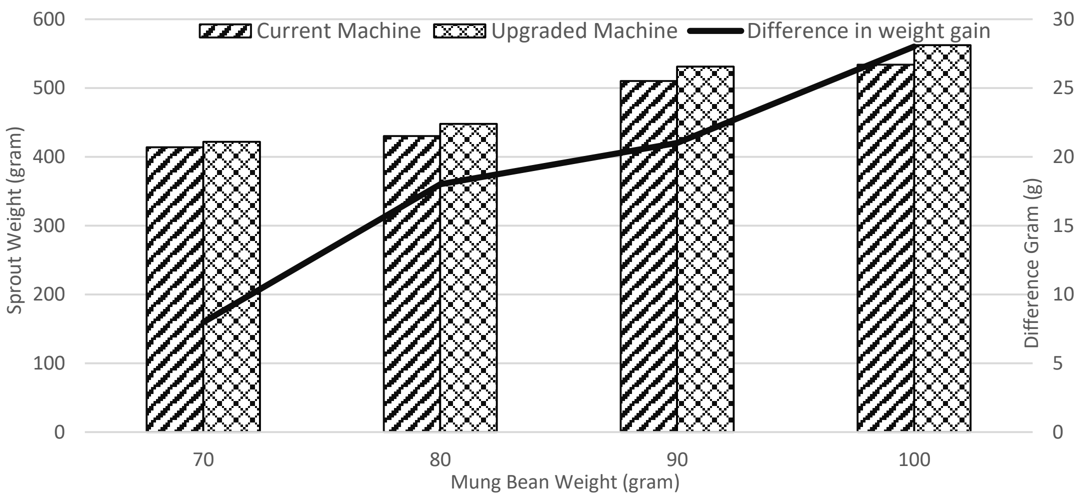


Fig. 8. Comparison weight of sprout from current machine and upgraded machine in different mung bean weight quantity

The upgraded machine yields more weight of sprout growth and subsequent overall production. This observation determines capability to replace IoT technology of sprout growth to replace current machine. The increased weight of the upgraded machine serves as a practical solution to the challenges in automated monitoring and the limitations of traditional methods and presenting solutions in a clear and ordered manner.

3.3 Water Absorbed by Sprout

In addition to weight comparison, the experiment assessed the water absorbed amount by mung bean sprouts. Figure 9 presents the data, indicating patterns in water absorption for different mung bean weight quantities between a current and upgraded machine.

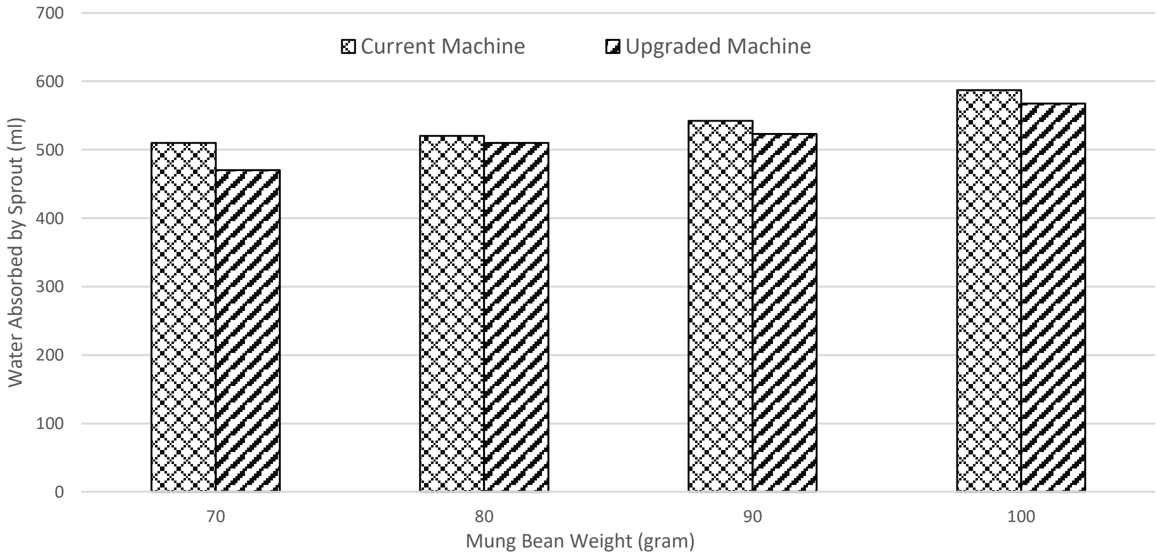


Fig. 9. Water absorbed by sprout from current machine and upgraded machine in different mung bean weight quantity

The results indicate that the upgraded machine's slightly lower water absorbed compared to current machine during the mung bean sprouting process for all weight quantities. This is due to watering sprout is in schedule circulation and not in non-stop watering. The results challenge conventional standards, exposing the upgraded machine's ability to achieve a more efficient watering pattern. The discussion emphasizes the project's success in advancing sustainable agricultural practices. Identifying challenges, such as minor fluctuations in water supply uniformity and contributing to problem solution on enhancing water control in agricultural settings.

3.4 Humidity and Temperature Monitoring

The humidity and temperature data analysis reveals distinction variations between the current and upgraded sprout machines. The temperature and humidity level are uncontrollable unless the study is conducted in green house field. The integration of humidity and temperature monitoring enhances the upgraded system’s ability to maintain consistent environmental conditions for optimal sprout growth.

Table 3
Average humidity and temperature readings

Mung Bean Weight (g)	Humidity (%)		Temperature (°C)	
	Current Machine	Upgraded Machine	Current Machine	Upgraded Machine
70	98	98	32.1	32.3
80	98	98	32.3	32.3
90	98	98	32.3	32.3
100	98	98	32.3	32.4

4. Conclusion

In conclusion, the research exposes the effects of an upgraded mung bean sprout system on plant growth parameters especially in weight and water absorbed. The experiments of sprout weight after cultivation, watering frequency schedule and environmental monitoring through humidity and temperature analysis presents a comprehensive picture of the upgraded machine's performance. Notably, the upgraded system consistently outperformed its current, comparably improving mung bean sprout yield. The integration of real-time data analysis platforms like Blynk provided distinction insights into environmental dynamics.

In the upgraded machine, water absorption is low but still produces a higher weight. This is due to watering sprout is in schedule circulation and not in non-stop watering. Sprout yields higher weight due to good growth where there is no stress (due to excessive watering).

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