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Points of interest

Developing an Internet of Things-based Red Onion Seed Storage System with Temperature Optimization to Increase Shelf Life and Quality

Agus Sugianto Indah Sulistiyowati Syamsudduha Syahrorini
Electrical Engineering Faculty of Science and Technology Electrical Engineering Faculty of Science and Technology Electrical Engineering Faculty of Science and Technology
Universitas Muhammadiyah Sidoarjo Universitas Muhammadiyah Sidoarjo Universitas Muhammadiyah Sidoarjo
Sidoarjo, Indonesia Sidoarjo, Indonesia Sidoarjo, Indonesia

giantoagsu26@gmail.com indah_sulistiyowati@umsida.ac.id syahrorini1@umsida.ac.id

Dwi Hadidjaja Rasjid Saputra
Electrical Engineering Faculty of Science and Technology
Universitas Muhammadiyah Sidoarjo
Sidoarjo, Indonesia
dwihadidjaja1@umsida.ac.id

Abstract— Storage conditions, particularly temperature and humidity, have a significant impact on the seed quality of red onions (Allium ascalonicum L.), a horticultural product. Weight loss, a higher chance of decomposition, and a reduction in seed viability can all result from improper storage. With a goal to enhance seed quality and shelf life, this project intends to design and construct an Internet of Things (IoT)-based red onion seed storage system with automated room temperature control. A DHT22 sensor for temperature and humidity monitoring, a load cell sensor for tracking changes in seed weight, a fan and servo motor as actuators to regulator air circulation, and a NodeMCU ESP8266 microcontroller as the primary controller were used in the system's design. The Blynk application received real-time monitoring data over an internet connection, enabling remote access and monitoring. The system can keep the storage room temperature between 17 and 20°C and the air humidity between 60 and 80%, according to test data. The system maintains the stability of the storage environment by operating automatically when environmental conditions surpass predetermined thresholds. As an IoT-based solution for storing onion seeds, this system works well.
Keywords— shallots, temperature control, Internet of Things, and seed storage.

Introduction

One of Indonesia's most valuable horticultural products is the red onion (Allium ascalonicum L.). One of the key elements that determines the success of shallot planting is the availability of high-quality seeds[1]. The availability of storage facilities for shallot seeds that are inappropriate for shallot features might result in damage from pathogenic fungus attacks, degradation, and diminished viability[2]. The quality of seeds during storage is significantly impacted by environmental factors including humidity and temperature[3].

Adequate climatic conditions, such as a room temperature of 15°–20°C and air humidity of 60–70%, are required to preserve the state of stored shallot seeds and prevent harm such as decay, reduced viability, and fungal assault. Weight loss of up to 12–13% can result of these two factors[4].

Usually, farmers continue to store seeds in open spaces or by drying them[5]. These techniques are nonetheless useless because they are unable to maintain stable storage conditions, which leads to the seeds' rapid deterioration and repeated financial losses for farmers, particularly when the sowing season does not align with the harvest season[6].

To attempt prevent shallot seeds from decaying, farmers currently preserve them using straightforward (conventional) techniques that lower the humidity of the seeds[7]. The surrounding environmental variables have a significant impact on this ancient procedure. Keeping the room temperature between 15° and 20°C is one strategy that can be applied. The product's viability, deterioration, and sprout growth are all prevented by optimizing the room temperature.

A great deal a lot of potential to change agricultural storage from passive to "smart" thanks to the growth of the Internet of Things (IoT)[8]. Real-time monitoring and remote control was made possible by the integration of sensors (temperature,

humidity, gas), actuators (Peltier controls,

fans), and cloud platforms. This enables for the autonomous maintenance of storage conditions and the storing of past data for analysis[9], [10]. A lot of research have created smartphone-accessible IoT-based temperature and humidity monitoring systems for agricultural product storage. The results of their study demonstrate that IoT systems can assist farmers in maintaining food quality by offering real-time information on storage conditions[11].

Based on the study's findings, it is possible to manage microorganisms and carry out automated monitoring and control by adjusting room temperature and IoT technology, which has a significant potential to increase the efficacy of product storage. However, studies that combine these two technologies in an integrated system and reach the optimal temperatures are still uncommon, particularly when it comes to Indonesian farmers preserving shallot seeds.

So the design of an Internet of Things-based shallot seed storage system with room temperature optimization technology to enhance quality and shelf life is the main emphasis of this study. By automatically monitoring and controlling the temperature, humidity, and weight of onion seeds, this system is intended to preserve seed quality and increase shelf life. It is envisaged that this technology will assist farmers in keeping high-quality seeds available all year around while also serving as a cutting-edge approach to smart agriculture in the digital age.

METHODOLOGY

Initial research and information gathering, planning, the first product format development, initial field trials, trial result revisions, main field trials, operational trial result revisions, final product revisions, and finally product dissemination and implementation comprise the stages of research and development.

Figure 1. Implementation Block Diagram

The initial phase involves identifying issues and gathering useful information for the study. To improve comprehension, a literature review is the initial action taken.

System Block Diagram

Figure 2. Block Diagram of Tool Design

Several integrated components create the block diagram of this Internet of Things-based shallot seed storage system with room temperature optimization. The NodeMCU ESP8266 microcontroller receives the data from the DHT22 sensor, which measures the storage room's temperature and humidity in real time. The NodeMCU ESP8266 microcontroller works to

keep the room temperature at the ideal level to stop the formation of bacteria and mold based on the sensor data.
The servo motor serves as a dumper control. The dumper will open when the temperature rises above 20°C and close when it falls below 15°C. To facilitate remote system monitoring and control via smartphone, currently measurement data and device status are transmitted to the Blynk cloud. In order to identify weight variations that take place during storage, this gadget is additionally outfitted with a sensor to detect seed weight. In combining these elements, this gadget can effectively and automatically preserve the quality of shallot seeds and increase their shelf life.

System Flow Chart

Figure 3. System flowchart
The image's flowchart describes the operation of an Internet of Things-based shallot seed storage system that uses a DHT22 sensor to control temperature. The NodeMCU ESP8266 must first be initialized before the system can connect to the internet. NodeMCU will use the load cell sensor to measure the weight of the seeds and the DHT22 sensor to measure temperature and humidity once the device is up. Blynk will immediately display the load cell sensor readings' results the temperature threshold as has been specified will be compared with the DHT22 sensor. The mechanism will trigger the servo to close the damper if it detects a temperature below 15°C. In contrast, the servo will activate and open the damper to lower the storage room's temperature if it reaches 20°C. After that, the temperature information and device status are transmitted to the Blynk cloud, where they are seen in real time on a smartphone through the Blynk app. To maintain stable storage conditions in compliance with the established requirements, this procedure will be ongoing.

Software Design
The goal of software design are to create applications that manage and run the Shallot Seed Storage system, which is based on the Internet of Things. The following software was utilized in the system's design:
Arduino IDE
Program code is written, edited, compiled, and uploaded to microcontroller boards using the official Arduino IDE software (Integrated Development Environment). Both novices and experts will find this software easy to use thanks to its straightforward interface and streamlined C/C++ programming language[12].

Figure 4. Arduino IDE display
The Arduino IDE software interface, which is used to create code and upload applications to the NodeMCU ESP8266 microcontroller, displays in Figure 4. An example of the code used to read the DHT22 sensor's temperature and humidity is shown in the sketch.
Blynk Cloud
The server system at the core of the Blynk IoT platform is called Blynk Cloud. Blynk Cloud allows users to remotely monitor connected devices through an internet connection by managing data, connections, and IoT application settings[13].

IOT Project Blynk + NodeMCU ESP8266 Monitor Suhu - Kelembaban Sensor DHT11 dan kendali LED via Internet

Figure 5. Blynk Cloud Display
The Blynk cloud interface, using an internet connection to track the temperature and humidity from the DHT22 sensor in real time, is depicted in Figure 5 [14].
Hardware Design

Figure 6. Hardware Design

IoT-based shallot seed storage system using a NodeMCU ESP8266 hub The main control system is linked to a load cell sensor to track the weight of the seeds that get stored, as well as a DHT22 sensor to measure the temperature and humidity in the storage area. Additionally, a servo motor controls the dumper's operation, assisting with cooling and air circulation when the room temperature rises. An adapter that is attached to the NodeMCU powers the entire system by providing voltage to each component. With this circuit arrangement, the NodeMCU can use sensors to gather information about its surroundings and regulate the fan and servo based on temperature readings. The following table shows the pin configuration associated with each component.

RESULTS AND DISCUSSION

Hardware Design Results

The goal of the hardware design for an Internet of Things (IoT) integrated shallot seed storage system is to produce a system that can automatically monitor and regulate the shallot seed storage room's conditions. The NodeMCU ESP8266 is utilized as the primary control element due to its inherent WiFi connectivity and data processing capabilities. This microcontroller is involved in both delivering the monitoring data to the Blynk platform for real-time display and receiving and processing information depending on the temperature value provided by the DHT22 sensor.

Figure 6. Hardware

Software Design Results

The Blynk app on a smartphone linked to the hardware system over the internet is used in the system's software design. The NodeMCU ESP8266 microcontroller served as the data processing hub for the software system, which was created using the Arduino IDE. A DHT22 sensor is used by the program to measure temperature and humidity, and a load cell sensor is used to periodically measure variations in seed weight. The microcontroller uses the information from the sensor readings to make decisions in the autonomous temperature control system.

The parameters displayed on the Blynk application screen are temperature, humidity, seed weight, and cooler status. This system is equipped with a feature to perform automatic set point setup, making it easier for users to adjust the temperature and humidity. The designed Blynk application display can be seen in the image.

Figure 7. Software Design Results

Control System Test Results

Testing of the control system was done to find out how the cooling fan and servo motor reacted to variations in the storage room's humidity and temperature. Temperature and humidity degrees changed during testing, and the actuator's state was then monitored using the preset control logic.

The control system displays that the servo motor and cooling fan may adjust to variations in storage room temperature in accordance with the preset logic based on test results. The cooling fan and servo motor turn on when the temperature rises above 20°C. In the meantime, the control system will turn off the cooling fan and servo when the temperature drops below 20°C. This situation indicates that the planned system is being followed by the control system.

Overall System Test Results

The Internet of Things (IoT)-based shallot seed storage system was tested ten times between November 24, 2025, and December 21, 2025. Temperature in the storage room, air humidity, variations in seed weight, and the cooling system's functioning state were among the variables noted.

The storage room temperature ranged from 17 to 20 degrees Celsius, according to the test findings. The cooling system was operating during the first test as the temperature was registered at 25 degrees. The cooling equipment was turned off in further tests because the storage room temperature was successfully kept below 20 degrees. This demonstrates that the control system maintains the ideal temperature in the storage room and operates in accordance with the design logic.

During testing, the air humidity value exceeded 40% to 80%. The humidity was measured at 40% in the first test, then rose and tended to stabilize between 60% and 80% in further testing. This range of humidity is still consistent with the characteristics of bibit penyimpanan bawang merah, therefore it is not reflective of extreme conditions that could lead to bibit kerusakan.

There was no weight loss from 0.50 kg to 0.50 kg during the testing period, according to the results of the shallot seedlings' weight monitoring. The weight gain suggests that the seeds in storage were stable and did not significantly lose weight over the testing time.

The system's capacity to keep the storage room's temperature and humidity at ideal levels is demonstrated by the stability of seed weight.

Overall, the test findings demonstrate that the IoT-based shallot seed storage system can successfully monitor and regulate storage room conditions. When the temperature rises beyond the designated limit, the cooling system will turn on; when the temperature falls within the designated range, it will turn off.

This demonstrates how well sensors, actuators, microcontrollers, and the Blynk program work together to serve the research goal of preserving the quality and shelf life of shallot seeds.

Conclusion

This study focuses on tracking the temperature, humidity, and weight of shallot seeds with storage room temperature management based on the outcomes of the IoT-based shallot seed storage system's design, implementation, and testing. After initial testing using actuator responses in line with the preset logic, the test results demonstrate that the system is capable of maintaining the storage room temperature within the range of 17–19 degrees.

The storage room's air humidity was consistent during the testing period, ranging from 60% to 80%, according to humidity monitoring. These circumstances do not point to any severe circumstances that might have an impact on seed quality, and they are nonetheless consistent with the storage characteristics of shallot seeds.

Additionally, the weight of shallot seedlings was monitored, and the results showed steady, gradual weight changes, culminating in a final weight of 0.50 kg. The stability of the weight variations shows that the system-controlled storage area can sustain ideal environmental conditions. Larger-scale development of this system as a smart storage solution for the agriculture industry is possible.

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