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# THE EFFECT OF INTEGRATING IOT SYSTEM IN THE SMART FARMING OF RED ONION (*ALLIUM CEPA*)

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**Abstract:**

Smart farming is pivotal in advancing agriculture, offering innovative solutions to optimize crop yields and monitor plant growth. This study proposes the use of the Internet of Things (IoT) in smart farming to determine the optimal watering interval for red onions (*Allium cepa*). The system incorporates Arduino technology, utilizing a water pump and humidity sensor for automated irrigation. Three watering schedules were tested: 8, 12, and 18 hours. The results indicate that an 8-hour interval yielded the highest growth (3.5 ± 1.20 cm) within three weeks, followed by 12 hours (3.4 ± 1.33 cm) and 18 hours (2.0 ± 0.67 cm). Factors such as soil type, nutrition, and environmental conditions may influence these outcomes. Future work, including greenhouse cultivation, is suggested to enhance data precision and agricultural productivity.

**Keywords:**

Smart Farming, Arduino, Internet Of Things, Watering Interval, *Allium Cepa*.

## Introduction

Agriculture forms the backbone of human civilization, driving societal progress through continuous innovation. Over the years, advancements in farming systems, such as soil-based, hydroponic, aquaponic, and aeroponic techniques, have revolutionized agricultural practices

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(Saiz-Rubio & Rovira-Más, 2020). The traditional farming methods demand significant labour, resources, and financial investment. The cultivation of the red onion plant, commonly known as *Allium cepa*, was the main subject of the study. This plant is currently cultivated all over the world, particularly in zones with moderate climates (Marefati et al., 2021) and has an excellent source of bioactive compounds and phytochemicals (Kumar et al., 2022) This spice plant is a member of the genus *Allium* and family *Amaryllidaceae* (Dorrigiv et al., 2021). More than 175 countries currently produce *Allium cepa*, which was first produced in Afghanistan, Iran, and the USSR (Suleria et al., 2014). Folic acid, vitamin B6, magnesium, calcium, potassium, and phosphorus are all present in considerable concentrations. *Allium cepa* is sensitive to water stress and requires frequent and light irrigation to avoid water deficiency (Kumar et al., 2007). In order to improve growth efficiency and resource management, this study focuses on creating an Internet of Things (IoT) system based on Arduino for *Allium cepa* farming.

According to Saleem et al. (2020), the IoT system is a technology based on integrating sensors into commonplace objects and employing connectivity to make it easier for information to be exchanged and used for several purposes. IoT systems enhance traditional agriculture by automating processes, improving data accuracy, and enabling real-time monitoring. It facilitates direct communication between devices without intermediaries, streamlining processes like automatic irrigation. For the farmers, they can concentrate on figuring out how to increase their farms' size without worrying about manpower. Prakash et al. (2023) stated that a cloud computing-based monitoring and storage system can be adopted for measuring soil characteristics, crops, environmental, and other parameters during in-field operations. Numerous tools and devices, such as Raspberry Pi, Arduino, and Micro: Bit and so on, can be used to build a complete IoT system. Every system has pros and cons of its own. For instance, Raspberry Pi's potent Central Processing Unit (CPU) makes it function like a tiny computer capable of performing intricate calculations. However, this system's complexity and high costs pose significant challenges.

Arduino offers a better solution for creating a basic and cheaper IoT system. Due to Arduino's simplicity and adaptability, it has emerged as the top choice for many manufacturers, students, and even enthusiasts. The aim and purpose of the Arduino platform is to simplify and ease the production of electronic prototypes. Arduino adopted an open-source strategy, allowing anybody to change, edit, and distribute its source code without facing legal repercussions. This led to a massive growth in the number of Arduino users and the open-source community. A complete Arduino project is built with microcontrollers, electronic components, and some simple-to-learn coding. The Arduino board has a variety of input and output ports that enable users to connect it to additional electronic components, like sensors and actuators, to enhance the project's interest. A wide variety of projects, including robotics, automatic systems, sensor networks, interactive devices, and many electrical projects, can use Arduino. The community is eager to assist one another, and most issues that newcomers have can typically be solved with a quick search in the forum or hub.

**Literature Review**

This section discusses the Internet of Things (IoT) systems in smart farming. Along with a sample project that shows how the most basic IoT system works, this section also describes the type of Arduino board used in this study.

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***IoT System***

The earliest recorded history dates of IoT systems came from John Romkey's invention, which allowed the operation of a toaster over the internet (Suresh et al., 2014). Additionally, Shafique et al. (2020) stated that IoT devices are a network of networked devices that send and act to enable information sharing across various platforms. According to Saleem et al. (2020), the IoT system is a technology based on integrating sensors into commonplace objects and employing connectivity to make it easier for information to be exchanged and used for several purposes. To progress the study of IoT technology, computing professionals will increasingly employ various tactics (Ali et al., 2020). Implement machine learning and deep learning, for instance, into an IoT system. Said and Masud (2013) noted that IoT devices offer extensive connectivity. There are far more daily things available than people, so this is true. A thorough understanding of machine learning and AI techniques is essential for advancing IoT systems. They should also consider what research is being done to enhance IoT technologies (Din, 2023).

IoT is a network of connected devices communicating with one another, the cloud, and other IoT devices to share data. Consider an electrical device like a phone, computer, smartwatch, air conditioner, washing machine, or television. The ability to control our phone or laptop using a smartwatch or television is undeniably fascinating. Regardless of the device commonly used, if it has internet access, IoT will offer many benefits and conveniences for everyone. A specific device is not required to operate another IoT device. For instance, to control every device in a smart home, installing and opening a particular program is needed. However, every IoT gadget can be operated at home using a smartwatch or the car's dashboard if it is an IoT system. The restriction on using the same brand or gadget to operate other devices will no longer be an issue with IoT systems.

***General Overview of IoT in Agriculture***

IoT systems are poised to transform business and agricultural practices. The industry's automation can be maximized to boost productivity and cut costs. IoT systems can be used in automatic irrigation or fertilization systems for farms. The IoT system can be managed by code or an application. The farmer only needs to specify the length of the irrigation and fertilization cycles, while nature will handle the rest. The system will now automatically manage the transmitter's functionality. As a result, farming has become simpler. Farmers can concentrate on figuring out how to increase their farms' size without worrying about manpower.

Furthermore, IoT can track every factor that influences how a plant grows. IoT systems can use many sensors, such as pressure liquid level sensors that can detect water pressure in the soil, to monitor all the factors affecting how a plant grows. Additionally, by monitoring the outside temperature, a temperature sensor can change the duration of watering automatically. Besides that, for the farmer organisation, an IoT system can generate and track large amounts of data that are often of better quality than data generated traditionally. The IoT system offers higher granularity, greater accuracy, more significant heterogeneity, more accurate real-time data, and substantially larger volumes than traditional data (Brous et al., 2020). As a result, the organisation can gather more trustworthy and accurate data for research purposes or modify farming practices to allow plants to develop healthily and productively.

This study aids in acquiring a comprehensive understanding of the captivating subject of the IoT. Moreover, this endeavor assists in determining the optimal watering schedule for specific

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plants, enabling the capture of crucial information for potential future use. Ultimately, this effort enhances agricultural productivity and addresses the global issue of food insecurity.

### *Role of Arduino in IoT System*

A lot of research has been done using Arduino. David et al. (2015) presented a smart home solution by using Arduino, which is affordable and effective. The hardware interface module and the software communication module are the two primary modules of this system. Vishnu et al. (2018) proposed a system that is an Android mobile application with an electric Arduino-controlled circuitry that functions as an alarm that overcomes the disadvantages of existing systems. The Blinking LED project by Rossano et al. (2018) introduced algorithms and basic programming concepts to the students. They produced a project that can control the blinking frequency of the LED by using the Arduino programming. This programming language was straightforward, allowing anyone to pick it up quickly and begin working on their projects.

The Arduino Uno board used in this study has several features constructed using the ATMEGA 328P microcontroller. This board, for example, can manage several digital inputs and outputs, analogue inputs, pulse width modulation (PWM) outputs, and more. Additionally, the Arduino Uno has a USB connector that enables users to connect it to the computer to begin programming before uploading it back to the board. According to Kumar et al. (2015), there are several uses for the Arduino ATMEGA 328 microcontroller, another name for Arduino Uno, including industrial and scientific settings. The automation process industries can extensively use these Arduino ATMEGA 328 microcontrollers. However, even though this board is already capable of managing almost all projects, it still has some limitations, such as an insufficient number of digital input and output pins.

## Methodology

The experimental setup consisted of an Arduino Uno microcontroller, micro submersible water pumps, soil hygrometer humidity detection modules, a relay module, a 9V heavy-duty battery, and a 9V battery snap. After assembling all the components, three red onions (*Allium cepa*) were planted in three separate pots labelled as P1, P2, and P3 as shown in Figure 1.

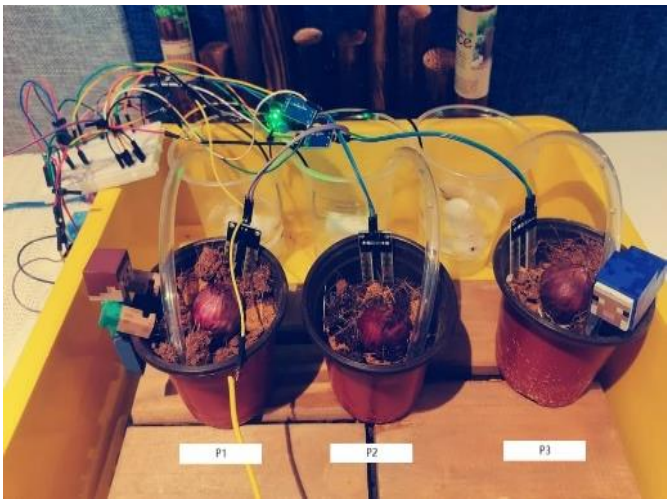


**Figure 1: *Allium Cepa* in P1, P2, and P3**

**Volume 9 Issue 37 (December 2024) PP. 310-316**
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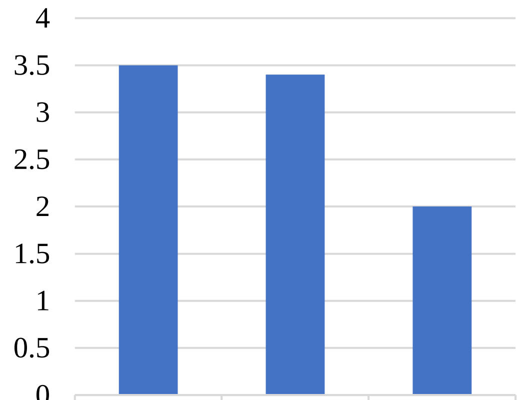
Tubes A, B, and C connected the water reservoirs to the soil in pots P1, P2, and P3, respectively. The transparent tubes were angled into three separate water-filled cups. The system used 5V and GND ports to power the 5V relay module. The 5V relay module was then attached to the water pump to control the timing of the water pump. The soil hygrometer humidity detection module was used to get the water level inside the soil. The Arduino Uno acted as the system's brain, controlling the water pumps via the relay module. When the soil moisture dropped below 40%, the system automatically activated the water pumps to maintain optimal hydration. The watering intervals were set to 8, 12, and 18 hours for P1, P2, and P3, respectively.

**Findings and Discussion**

Plant growth was measured daily for three weeks. Soil moisture levels were monitored continuously using the hygrometer modules, and plant height was recorded using a standard ruler. Growth patterns were analysed to determine the most effective watering interval. Within three weeks, P1 had grown the greatest of all three plants, totaling 3.5 ± 1.20 cm under an 8-hour watering interval. Next in line was the P2, which received watering at 12-hour intervals. P2 has grown by about 3.4 ± 1.33 cm overall. P3 has the smallest overall growth, growing about 2.0 ± 0.67 cm. Watering P3 occurs every 18 hours. This study concludes that the best watering interval for the growth of *Allium cepa* must be within an 8-hour watering interval. Figure 2 shows the total growth of *Allium cepa* during watering intervals of 8, 12, and 18 hours.




| | 8 hours | 12 hours | 18 hours |
|---|---|---|---|
| Total Growth (cm) | 3.5 | 3.4 | 2 |

**Figure 2: The Total Growth of *Allium cepa* during Watering Intervals of 8, 12, and 18 Hours**

Kanton et al. (2003) stated that *Allium cepa* needs to be watered every three to five days. Based on Pejic (2014), *Allium cepa* is very sensitive to water stress under climate conditions. A few factors should be considered for the optimal growth of *Allium cepa,* such as the type of soil used, the nutrition source for onions, the weather, and the type of onion. Wakchaure (2021) stated that even the low water stress impacts its photosynthesis and other physiological mechanisms both at the intracellular and the whole plant level, often leading to reduced growth, bulb yields, and overall productivity. According to Kumar et al. (2007), few research studies have been conducted to characterize an appropriate irrigation level for *Allium cepa*, but the irrigation water management varies with soil-agro-climatic conditions and with irrigation systems. It is recommended that it be further expanded by planting the *Allium cepa* inside a

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greenhouse to obtain the most accurate results. This study can potentially enhance agricultural production and contribute to the advancement of Malaysia's agricultural system.

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