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Rancang Bangun Sistem Penyiraman Otomatis dan Mandiri Energi Berbasis NodeMCU Pada Tanaman Bayam

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ABSTRACT

Spinach is a nutrient-rich leafy vegetable that is often grown in Indonesia. Although it grows quickly, it requires quite intensive care, especially when it comes to proper watering to maintain soil moisture for optimal growth. Manual watering is considered less efficient and can often result in improper water application, either too much or not enough, which can hinder optimal plant development. As technology advances, the utilization of automatic watering systems that rely on soil moisture sensors is considered an efficient method in an effort to save water usage, reduce errors in the watering process, and increase crop yields in agriculture. This research was conducted with the aim of designing and developing a prototype of an automatic watering system that can maintain soil moisture suitable for spinach plant growth. The implementation of this system occurs by monitoring soil moisture at all times and operating the water pump when soil moisture drops below a predetermined threshold. Trial data showed that the system was effective in maintaining soil moisture at around 54% by using 629 ml of water during sunny weather. Thus, this automatic watering technology could be a way to address the problem of water scarcity and adapt to climate change, while supporting more productive and sustainable agriculture.

ABSTRAK

Tanaman bayam adalah jenis sayuran berdaun yang kaya nutrisi dan sering ditanam di Indonesia. Walaupun tumbuh dengan cepat, tanaman ini membutuhkan perawatan yang Cukup intensif, terutama dalam urusan penyiraman yang benar agar kelembaban tanah tetap terjaga demi pertumbuhannya yang optimal. Penyiraman manual dinilai kurang efisien dan seringkali dapat mengakibatkan pemberian air yang tidak tepat, entah terlalu berlebihan atau kurang, yang bisa menghambat perkembangan tanaman yang optimal. Seiring dengan kemajuan teknologi, pemanfaatan sistem penyiraman otomatis yang bergantung pada sensor kelembaban tanah dianggap sebagai metode yang efisien dalam upaya untuk menghemat penggunaan air, mengurangi kesalahan dalam proses penyiraman, serta meningkatkan hasil panen di bidang pertanian. Penelitian ini dilakukan dengan tujuan merancang serta mengembangkan prototipe sistem penyiraman otomatis yang dapat mempertahankan kelembaban tanah yang sesuai untuk pertumbuhan tanaman bayam. Pelaksanaan sistem ini terjadi dengan cara memantau kelembaban tanah setiap saat dan mengoperasikan pompa air apabila kelembaban tanah menurun di bawah ambang batas yang telah ditetapkan. Data uji coba menunjukkan bahwa sistem tersebut efektif dalam menjaga kelembaban tanah pada kisaran 54% dengan menggunakan 629 ml air saat cuaca cerah. Dengan demikian, teknologi penyiraman otomatis ini bisa jadi jalan keluar untuk menangani masalah kelangkaan air dan menyesuaikan diri dengan perubahan iklim, sekaligus mendukung pertanian yang lebih produktif dan berkelanjutan

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KEYWORDS

Automatic Watering, Sustainable Agriculture, Spinach Plants

INTRODUCTION

Spinach is a leafy vegetable that is popular in various parts of the world, including Indonesia (Pamungkas, 2023). Spinach contains excellent nutrients such as vitamin A, vitamin C, iron, and calcium (Sari, et al, 2021), making it a healthy and nutritious food. Many farmers and plant cultivators are interested in growing this plant because of its rapid growth and short harvest time (Siagian, et al, 2024). However, despite its rapid growth, spinach requires intensive care, including proper watering to ensure optimal growth (Masdor, 2019). Proper watering of spinach plants is essential to maintain soil moisture so that the plants can grow vigorously. However, manual watering processes are often inefficient (Fadillah, et al, 2024).

Many farmers or plant cultivators face difficulties in determining the appropriate timing and amount of water for their plants. Excessive or insufficient watering can have adverse effects on spinach growth (Ardiansyah, 2022) and may even damage plant roots. Therefore, an appropriate irrigation system is needed to maximize harvest yields (Puspita, 2024).

Therefore, it is necessary to water the plants effectively to water spinach plants. Along with technological advances, many automation solutions have been introduced in agriculture, including automatic irrigation systems (Putra, et al, 2024). This system allows plant watering to be done without human intervention, using soil moisture sensors that measure soil moisture levels in real-time (Effendi & Ramadhani, 2022). If the soil moisture falls below a set threshold, the sensor will trigger the system to release water into the soil. Of course, this can reduce time, labor, and water usage more efficiently, as water is only provided when the plants truly need it.

Automatic irrigation systems based on soil moisture sensors are ideal for spinach plants, which require sufficient soil moisture for growth (Fadillah, et al., 2024). With this technology, farmers no longer have to continuously water their plants manually. This automatic irrigation system can also prevent errors such as Too much water can cause plant roots to become waterlogged and rot, while too little water can hinder plant growth (Jingga, et al, 2022). Additionally, environmental factors that complicate water management are also a significant issue in modern agriculture (Budhiawan & Sushanti, 2022). Unpredictable climate change, such as rising temperatures and irregular rainfall, has made water availability increasingly limited (Suprapto, 2022). This necessitates an innovation that can address these issues.

This study aims to design and develop a prototype automatic watering system for spinach plants based on soil moisture sensors; this prototype aims to provide an efficient solution for cultivating spinach, optimizing water consumption, and increasing overall agricultural productivity. The use of automatic irrigation technology not only benefits the growth of spinach plants,but also ensures that plants receive the right amount of water while providing environmentally friendly and sustainable agricultural techniques (Kusweanto, 2023), while still ensuring that plants receive the right amount of water at the right time.

METHODS

The method used to design this NodeMCU-based automatic irrigation system is a research and development method, which begins with a needs analysis through literature study to maintenance of the design that has been made and with separate test data.

The data collection techniques used by researchers in this study are:

- Direct observation, conducting direct observations to see the performance of automatic irrigation tools.
- Literature study, reviewing literature related to automatic irrigation system prototypes and solar panels, as well as articles and journals relevant to the research conducted to understand the basic theory and existing solutions.
- Browsing, searching for additional information via the internet to broaden understanding of the innovations or tools developed by the researcher.

The observation data was analyzed using descriptive statistics, which involved describing the observation results in tables and percentages.

RESULTS AND DISCUSSIONS

This automatic irrigation system was designed using NodeMCU as the microcontroller and solar panels as the power source.

Figure 1. design and construction installation

The design consists of several main components. The following are the design components that have been created:

1. Microcontroller
   The microcontroller consists of several components, including NodeMCU ESP 8266, humidity sensor, relay, pump motor, and LCD display.

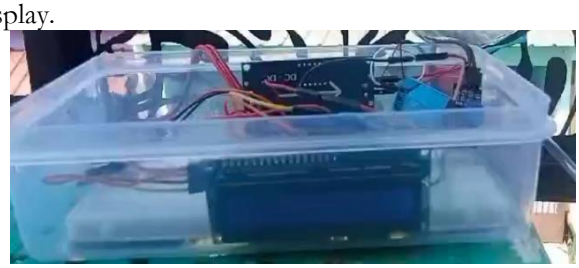

Figure 2. Microcontroller Display

2. LCD Display
   The LCD displays humidity data obtained from the sensor and the pump motor status.

Figure 3. LCD Display

3. Solar Panel
   The solar panel generates electrical voltage with a maximum power of 20 Vdc. The voltage is then reduced by a buck converter to 5 Vdc so that it can operate the design.

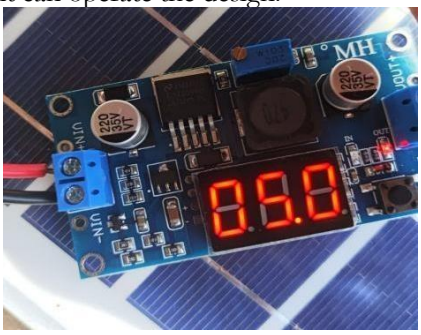

Figure 4. data on solar panels

The components of the automatic watering system can function as intended. The pump can supply water to the hose when the sensor detects insufficient moisture in the growing medium.

Table 1. component performance test

No.	Component	Result
1.	Solar Panel	Function
2.	Node-MCU	Function
3.	Relay	Function
4.	Pump Motor	Function
5.	Sensor	Function
6.	LCD	Function
7.	Buck Converter	Function

Next, the microcontroller and pump capabilities were tested to maintain the desired humidity level, which is a minimum humidity of 54% and a dryness of 46%. If the sensor detects that the dryness of the planting medium is below 46%, the water pump will stop or turn off. If the sensor detects that the dryness of the planting medium is above 46%, the pump motor will pump water. Below is a table showing the LCD display functions that read data on the microcontroller.

Table 2. test the device for Moistuire

LCD Display	Moistuire	Pump
	28,6%	OFF
	47%	ON
	57,1%	OFF
	27,6%	OFF
	30%	OFF

	57,1%	ON

Water requirements for 10 spinach plants grown together in a container with a volume of 8 liters

Table 3. Functional Testing of Plant Design

NO.	AMOUNT OF WATER (ML)	PLANT HEIGHT	LEAF WIDTH (P.L.K) K=0,651	DATE
1.	0	13 cm	25, 740 cm²	13 November
2.	630	14 cm	26, 893 cm²	15 November
3.	600	14 cm	27, 065 cm²	16 November
4.	590	14 cm	27, 100 cm²	17 November
5.	674	15 cm	29, 280 cm²	19 November
6.	630	15 cm	29, 282 cm²	20 November
7.	650	15 cm	29,295 cm²	21 November

CONCLUSIONS

The design of the Automatic Watering Technology initiated by researchers makes it possible to maintain the moisture level required by plants, thus providing a solution for adapting to climate change. The design can maintain a moisture level of 54%. If the dryness level exceeds 46%, the water pump will activate delivering water to the plants. This will maintain the moisture conditions required by plants by regulating the desired moisture level on the Automatic Irrigation microcontroller. The amount of water tested on plants was 629 ml in normal sunny weather conditions. Water-efficient irrigation management is very important to maintain the quality and quantity of agricultural production amid extreme climate change.

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