Development of controlled drip irrigation with lock time system

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Abstract. The utilization of controlled systems in drip irrigation can increase land productivity and can minimize water usage in the dry season. This irrigation system can reduce water loss and can increase the effectiveness and efficiency of agricultural activity. The purposes of this study were to develop and to analyze the ability of controlled drip irrigation with lock time system for watering crops on time and according to the needs. The research method of this study was research and development (R & D) method, starting from designing a control system, prototyping, functional testing, field testing, and data analysis. Based on the test results, the controlled drip irrigation system that had been developed had high time accuracy, with an error percentage of 0.9%. The response of the solenoid valve function had high sensitivity, with an R2 value of 0.99%. This system had high spray consistency with an average spraying error rate of 1.3 ml per emitter. Based on these results, it can be concluded that the controlled drip irrigation device with a lock time system that had been developed can function properly and is suitable for watering crops on time and according to crop needs.

1. Introduction

The need for water for plants is a serious problem, especially during the dry season, causing lower plant productivity because the development of flowers and seeds in plants is decreasing. Besides that, the most massive impact of the dry season on plants is that it can cause death in plants if water needs are not met. This is consistent with the statement that water deficit negatively affects the development of flowers and seeds. Water stress is reported as one of the causes of low plant productivity [1]. This is also in accordance with the statement [2] which states that one of the efforts to increase the productivity of dry land is the development of water-efficient supplementary irrigation in the dry season. On land with limited water sources, the drip irrigation system can save water use because it can minimize water losses such as percolation, evaporation and surface runoff.

One of the efforts that can be made to improve plantation activities, especially for plant nurseries and production, is to increase the application of technology in the plantation sector. The application of appropriate agricultural technology can increase production and motivation of farmers to carry out effective and efficient plant nurseries. With high motivation, it will be easy to provide innovation for farmers. Until now, the application of technology for precision farming in plant nurseries is still minimal, so it becomes a limitation in future development [3].

One of the technologies that can be applied to improve plant nurseries is a drip irrigation control system. A controlled drip irrigation system is one of the irrigation technology solutions that can be
used to save water during watering because this irrigation has low pressure and small discharge with the water supply system applied only to the area around plant roots through an emitter system. This is in accordance with the opinion [4] which states that the drip irrigation installation is a series of irrigation equipment components that are arranged in such a way that they can release water drips. The design of drip irrigation installation is needed to make water use more efficient because drip irrigation can concentrate water supply in the root area, so that plants will be easier to absorb water for their growth. This system can increase the production of plant seeds, but the development of this system is still lacking in Indonesia, especially in the nurseries of plantation crops. Therefore, the development of controlled drip irrigation with lock time system on plants is urgently needed. The purposes of this study were to develop and to analyze the ability of controlled drip irrigation with lock time system for watering crops on time and according to the needs.

2. Methods
This study was a research and development (R&D) study. The development of controlled drip irrigation with lock time system starts from the designing control system, prototyping, functional testing, field testing, and data analysis.

2.1. Time and place
This research was conducted from January 2020 to December 2020, which took place in the laboratory and experimental garden of Department of Agricultural Technology Education, Faculty of Engineering, Universitas Negeri Makassar.

2.2. Tools and materials
The equipment used in this research was a multimeter, Arduino microcontroller, SD Card, RTC DS3230, measuring cup, solenoid valve. The materials used in this research are water tanks, pipes, pipe joints, water, and emitters.

2.3. Drip irrigation design
The prototype of drip irrigation was designed to have one water reservoir and three block irrigation systems. The irrigation system block path was made of ½ inch PVC pipe, with a water-holding volume of 300 L (Figure 1). Each line/block of the irrigation system was controlled by using a solenoid valve which regulates the volume of water entering the irrigation system block line. Each irrigation system block has ten emitters with a distance of 35 cm per emitter. Planting media using polybags with a diameter of 30 cm.

![Figure 1. Drip irrigation prototype design](image-url)
2.4. Control system mechanism

The control system mechanism used in this study was the open-loop control system, where the watering time set point written in the program was inputted on the microcontroller. The set-point was used to adjust the function of the actuator (solenoid valve) during the watering process with the aim that the watering process can be on time and the volume of watering was in accordance with what the plants need. The mechanism of the control system can be seen in Figure 2.

![Figure 2. Mechanism of control system](image)

2.5. Testing

The test was carried out in two stages, namely the functional test of control device components such as solenoid valves, sensors, and irrigation emitters. The second stage of the control system test was carried out by testing the response of the solenoid valve function based on the set-point time used which function continuously every day based on the set point of watering time that had been deferred in the program.

2.6. Data collection

The data collected in this study were data on the results of irrigation tools and control systems testing, which were carried out directly in the field. The data obtained from testing were in the form of RTC module calibration data, real-time test data for solenoid valve function, data storage on SD card, and irrigation spray volume data based on set point time.

3. Results and Discussion

3.1. Controlled drip irrigation prototype

The controlled drip irrigation prototype consists of several tool components. A water tank (reservoir) with a maximum water reservoir dimension specification of 300 l. The water from the storage tub was connected to a 1.5-inch PVC pipe in parallel that functions as an irrigation line. A 220 Volt solenoid valve installed at each inlet of the irrigation line pipe which was used to adjust the volume of water that comes out on/off based on the set-point time specified. The emitter could produce the volume of water according to the needs of the plant. The drip irrigation was needed to increase water use efficiency because drip irrigation can concentrate water supply in the root area so that plants will be easier to absorb water for their growth [5].

![Figure 3. Controlled drip irrigation prototype](image)
3.2. Calibrate the set-point time
The set-point time used to calibrate the timer function on the RTC module was 1, 3, and 5 minutes. The results of the calibration test showed that the time difference between the set-point and the reading time on the stopwatch was ±1 second (Figure 4). This difference was due to the fact that the command response on the microcontroller takes approximately 1 second to arrive at the calibration test actuator so that it could activate the actuator automatically according to the desired time. RTC test is carried out to find out whether the RTC can display the time correctly according to the real-time [6].

![Figure 4. Graph of time calibration results](image)

3.3. Solenoid valve response time
The data from the solenoid valve response test, which was carried out based on the time inputted into the program, which was 1-5 minutes, showed that the solenoid valve response had a very good regression value ($R^2=0.99$) (Figure 5). The difference between the time of the solenoid valve function and the time at the stopwatch was around 1-2 seconds. Based on these data, it showed that the error rate/difference between the time used for the solenoid valve function and the time at the stopwatch was very small. The valve time response measurement was a measurement of the delay in water flowing when the valve was open and closed [7]. The irrigation response produced when the valve was open had a delay of 2 seconds. This means that water flows after 2 seconds from the valve when the valve was on.

![Figure 5. Graph of response regression values solenoid valve.](image)

3.4. Data storage
Measurement data, both sensor data and irrigation time spraying, were received and stored in external memory (SD card) with a memory capacity of 4 GB. The data stored on the memory card was used in the form of an excel file according to the program commands used. The measurement data stored on the memory card were spraying time data, spraying date data, and some sensor measurement data.
Data was stored in real-time, and at each data reception, the SD card module saves data in the format of date, time, and several sensor readings. The output monitoring system and data recording on the Arduino microcontroller-based actuator could record the results of output measurements automatically on the SD Card every 15 minutes [6]. The series for data storage using an SD card module could be seen in Figure 6.

![Figure 6. SD card module circuit](image)

### 3.5. Set-point and spray volume

Spray volume testing was carried out with a set point time of 1 minute, 3 minutes, and 5 minutes. The time set-point was used to control the on/off function of the solenoid valve. Based on the test results, it was obtained that the average difference in the volume of droplets in each irrigation emitter was 1.3 ml, with the highest volume of water usually found in the first emitter and the last emitter (Figure 7). This was most likely because the greatest pressure in the pipe was at the beginning and at the end of the pipe. When the solenoid valve was open or on at the emitter, the flow of water from the manifold was blocked to the emitter so that the largest water discharge was found at the first and last emitter [4].

![Figure 7. Graph of average volume of water based on time](image)
4. Conclusion
Based on the research results, it could be concluded that the controlled drip irrigation with lock time system that had been developed works well for watering plants and was in accordance with the desired set point of spray time and volume of spray. This system could function properly and was suitable for watering crops on time and according to crop needs.

5. References
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