Monitoring System of Rice Plant Growth Using Microcontroller Sensor

H Lubis, R F Rahmat*, J Karansa, and S Purnamawati

1Faculty of Engineering and Computer, Universitas Harapan, Medan, Indonesia
2Department of Information Technology, Faculty of Computer Science and Information Technology, Universitas Sumatera Utara, Medan, Indonesia

Corresponding Email: romi.fadillah@usu.ac.id

Abstract. Rice is one of the species belonging to the genus Oryza L, which covers approximately 25 species and is spread in the tropics and subtropical regions. Rice is a type of plant that requires care to grow. Each type of plant needs different characteristics of the growing media. The surrounding environment has an effect on the growth of rice plants for the quality of crop harvest to give maximum results. Rice productivity is largely determined by soil conditions, water level, humidity, and light intensity of the rice plant itself. Therefore rice plants must grow and develop in the hot climate with a lot of water vapor which includes rainfall, temperature, and sunlight. This rice monitoring system uses the sensors of soil moisture, air humidity, light intensity, water level, modems, Arduino Nano and Raspberry Pi. The test results were carried out only two days in 2 weeks which monitored the rice plants, especially Mekongga rice varieties by paying attention to the soil moisture, air humidity, light intensity, and water level.

1. Introduction

Rice is a kind of plant that is very easy to find, especially those who live in rural areas. Most people eat rice as a source of staple food. Rice belongs to the genus Oryza L, which covers approximately 25 species and is spread in tropical and subtropical regions, such as Asia, Africa, America and Australia [1]. Rice (Oryza sativa L.) is a staple food for almost all citizens in Indonesia [2]. Rice is a plant that requires treatment for growth

Each type of plant needs different properties and characteristics of the growing media. The surrounding environment has impacts on the process of growth and development of rice plants to have outstanding harvest quality. Rice productivity is mostly determined by soil conditions, water level, air humidity, and light intensity of the rice plant itself [3]. Hence, rice plants must be planted in tropical climates and contain large number of water vapor, including rainfall, temperature, light or sunlight [1].

Changes in light intensity, water level, humidity, and soil moisture significantly affect plant growth, especially rice plants. If farmers are not careful and monitor regularly, the growth of rice will not be optimal which leads to low quality of the harvest [4].

The development of information technology, especially computational technology, eases the human to conduct numerous works that were done manually to be easier, faster and accurate regarding saving space, time and effort. Due to the existence of a more advanced technology system, it can be applied as an alternative to monitoring the development of rice plants using raspberry pi as a microcontroller.
Farmers should pay attention to the rice plants, starting from the caring to the harvest process to get an optimum quality of the rice. Farmers should take the water level at irrigation, soil moisture, air humidity, light intensity, and others into matters to improve the rice quality. Therefore a system is needed to monitor the supporting parameters of the growth of rice plants.

In this study, authors established a problem limitation to prevent the scope of the problem from expanding off of this study. The limitations of the problem are: The rice variety is Mekongga rice. Rice to be monitored are over the age of 68 days after seeding. The paddy area that will be calculated is 10 x 20 square meters (m²). The parameters are soil moisture, air humidity, light intensity, and water level during irrigation in the process of growing rice.

The purpose of this study is to monitor the growth of rice plants using raspberry pi as a microcontroller. The benefits of this study are facilitating farmers to monitor the development of rice plants easily and to become a reference for further research in the development of Science and Technology, especially the use of the Internet of Things (IoT).

Mekongga rice is a cross-breed between A2970 furrow rice originating from Arkansas, United States, with popular variety in Indonesia, namely IR64. The age of Mekongga rice is quite short, which is only 116 to 125 days, and physically the plant shape is upright with plant height ranging from 91 to 106 cm. The weight of 1000 grains of Mekongga is 28 grams, so the potential yield of this variety reaches around 8.4 tons per hectare [5]. This variety has good resistance to pests & diseases such as brown planthopper biotypes 2 and 3, and bacterial leaf diseases. Thus, farmers should no longer have to worry about the attack of pests and diseases. Due to its superiority, many regions have made Mekongga as a premium variety. This type of rice is very suitable to be planted in the lower area and is not suitable to grow in the highlands more than with a height of 500 masl.

A sensor is a tool to detect symptoms or signals originating from the changes in energy such as electrical energy, physical energy, chemical energy, biological energy, mechanical energy and so on. Examples of the sensor are the camera as sight sensor, ears as hearing sensor, skin as the touch sensor, LDR (light dependent resistance) as the light sensor, and others. Generally, the sensor consists of two types, namely, physical sensors and chemical sensors. Physical sensor is a sensor that detects a quantity based on the laws of physics. Samples of physical sensors are light sensors, sound sensors, temperature sensors, force sensors, and acceleration sensors. A chemical sensor is a sensor to detect the amount of a chemical by changing chemical quantities into electrical quantities, such as PH Sensors, gas sensors, oxygen sensors, explosion sensors, and others. The definition of sensors in an electronic system is, a circuit must be able to accept an input, such as sound and vibration that will be converted into electrical energy and processed to produce an output; usually the components chosen for these conditions are sensors and transducers.

One of the technologies that has been developed rapidly for environmental monitoring is a sensor. The benefits of microsensor include integration and portable, which increase the efficiency and speed, improve the reliability of the analysis process, and reduce the usage of sample and reagent. With this sensor technology, it is possible to do monitoring and measurement automatically and remotely with high accuracy and precision.

There is many previous research related to the conducted study. Kait et al. conducted research on paddy growth monitoring using wireless sensor network in 2007. The study shows a brief design of wireless sensor nodes used in the agricultural field, using the SMT type wireless sensor board [6].

Jerin et al. performed a study on plant growth monitoring system with a dynamic user interface. The authors created prototype for measuring plant growth using a machine learning algorithm [7].

An agricultural monitoring system: Soontranon et al. conducted field server data collection and analysis on the rice field in 2016. The research was conducted in Thailand for rice, corn, cassava, rubber, sugar cane, where the plants were the objects to measure temperature, rainfall, light density, soil moisture, and wind direction in the long run and users can access and obtain data via the web browser in the form of a field server [8].

Flores et al. conducted a study on precision agriculture monitoring System using a wireless sensor network and Raspberry Pi local server in 2016. The research used sensors at a low cost for temperature,
air humidity, soil moisture, luminosity, electrical conductivity, and PH where raspberry pi served as a local server. The data was sent and stored in SQL form, and the interface of the data was in the form of graphics (GUI) [4].

Ginting performed a quality monitoring system for vegetable plants in hydroponic planting media using Arduino in 2017. The study implemented Arduino Uno as a microcontroller or the main board with the support of several sensor devices [9].

2. Methodology
The general architecture of this research is shown in Figure 1.

![Figure 1. General Architecture.](image-url)
The stages to be carried out are:

1. Input
   A rice field with an area of 10 x 20 square meters (m$^2$) will be measured using four types of sensors, namely: soil moisture sensor, air humidity sensor, light intensity sensor (light sensor), and water level sensor. The sensor devices will be connected to Arduino nano.

2. Process
   In this process, water sensors will collect the data of water level found in the rice field where the irrigation carried out. The soil moisture sensor and air humidity sensor will measure the data of soil moisture and air humidity, while the light sensor serves to measure the intensity of light in the rice field. The data is in the form of analog signals that will be sent to Arduino nano to be calculated to obtain the results of the obtained data. The data will also be sent to raspberry pi where the raspberry pi task serves as the data processor with the help of a modem. This modem will be installed on raspberry pi which will help raspberry pi to connect it to the internet. The web server acts as a platform to service and process the data between Arduino nano, database, and client. The web server will receive all the data obtained and sent from raspberry pi. This data will then be stored in the database and ready to be processed and displayed to the client.

3. Output
   The data that will be obtained by the client is in the forms of graphs and tables. The graph will display the data at certain intervals and is always updated automatically as long as the system receives the data from Arduino nano. If the data changes significantly, a notification will appear on the graph. In this output process, the client will access a web page on the web server for monitoring. This page will contain a graph of water level, soil moisture, air humidity, and light intensity in the rice field, and the graph is always moving and updated automatically.

3. Result and Analysis

3.1. Implementation of System Design
   In the implementation, system monitoring was conducted using the PHP programming language, while the monitoring of soil moisture, air humidity, light intensity, and water level were using the C programming language. The hardware and software specifications used in making this system were Intel (R) Core Processors (TM) i5-3337U CPU @ 1.8GHz (4 CPUs), Windows 10 pro 64 bit Operating System, 4096MB RAM Memory, 500GB hard drive capacity, WinSCP version 5.13, Arduino 1.8.5., PuTTY 64 bit.

3.2. Implementation of Interface Design

![Figure 2. Main Page Design.](image-url)
3.3. System Performance Test

System performance testing was carried out to determine the average value or level of soil moisture, humidity, light intensity, and water. This test was carried out on the subjects of the Mekongga rice aged over 68 days since the seeding. After 68 days, the rice plants will be monitored with built tools.

![Figure 3. Mekongga Rice Field.](image)

The test of the system and tools performance that has been built was conducted by monitoring soil moisture, air humidity, light intensity and water level of the Mekongga rice field. The size of the monitored rice fields was approximately 10 x 20 square meters (m²), and the age of rice is over 68 days since the seeding.

![Figure 4. Test of Rice Plants using Sensor.](image)

3.4. Test Result

The sensors will be directly tested in a field with an area of approximately 10 x 20 square meters (m²). The test was only carried out in 2 days, one day in the first week and another the second week since the proper time for this test is 68 days from the time of seeding for the Mekongga rice variety. The results can be seen in table 1.

| No | Date and Time     | Water Level (cm) | Air Humidity (%) | Soil Moisture (%) | Light Intensity (Lux) |
|----|-------------------|------------------|------------------|------------------|----------------------|
| 1  | 2018/08/04 15:10:40 | 6                | 25               | 89               | 26327.4              |
| 2  | 2018/08/04 15:15:40 | 6                | 24               | 89               | 29128.6              |
| 3  | 2018/08/04 15:20:40 | 6                | 24               | 89               | 29324.5              |
The results of the table can also be seen in graphical form as follows:

|   | Date        | Time           | Value | Count | Result |
|---|-------------|----------------|-------|-------|--------|
| 4 | 2018/08/04  | 15:25:41       | 6     | 26    | 90     | 31478.2 |
| 5 | 2018/08/04  | 15:30:41       | 6     | 25    | 90     | 30825.3 |
| 6 | 2018/08/04  | 15:35:41       | 6     | 26    | 90     | 29889.6 |
| 7 | 2018/08/04  | 15:40:41       | 6     | 24    | 89     | 27776.7 |
| 8 | 2018/08/04  | 15:45:42       | 6     | 23    | 88     | 27744.6 |
| 9 | 2018/08/04  | 15:50:42       | 6     | 25    | 90     | 29678.9 |
|10 | 2018/08/04  | 15:55:42       | 6     | 27    | 90     | 32669.8 |
|11 | 2018/08/11  | 12:05:38       | 4     | 23    | 91     | 29128.6 |
|12 | 2018/08/11  | 12:10:38       | 4     | 24    | 90     | 26566.4 |
|13 | 2018/08/11  | 12:15:38       | 4     | 24    | 90     | 27445.7 |
|14 | 2018/08/11  | 12:20:39       | 4     | 23    | 90     | 27113.3 |
|15 | 2018/08/11  | 12:25:39       | 4     | 25    | 90     | 27787.8 |
|16 | 2018/08/11  | 12:30:39       | 4     | 26    | 92     | 32857.3 |
|17 | 2018/08/11  | 12:35:39       | 4     | 26    | 92     | 32654.5 |
|18 | 2018/08/11  | 12:40:39       | 4     | 26    | 91     | 31566.5 |
|19 | 2018/08/11  | 12:45:40       | 4     | 25    | 91     | 31115.7 |
|20 | 2018/08/11  | 12:50:40       | 4     | 25    | 91     | 30366.1 |
From the results of the monitoring, it can be seen that the condition of the rice field can change in a fairly short time. In the monitoring process, authors monitored the surrounding of rice fields such as soil moisture, air humidity, light intensity and water level which changes approximately every five minutes. From the monitoring results, it is shown that air humidity, soil moisture intensity of light often change and can conclude that the Mekongga rice varieties aged approximately 68 days old from the time of seeding require the proper environment. If heavy rains hit the fields and submerged in water and with low light conditions, the rice plants will likely to be damaged during their growth period, and the rice quality will be low.

4. Conclusion and Future Research
The conclusions based on the monitoring system testing for rice varieties are as follows:
1. This study applied Raspberry pi as a microcontroller and server to monitor the factors that influence the growth of rice plants to produce good quality rice.
2. Based on the two days testing in the first and second week, each sensor has obtained a stable average data following the environmental condition of rice fields. Rice plants will deteriorate if air humidity and soil moisture are in bad condition.
3. This study used four sensors to monitor the rice plants. In further research, the addition of more sensors to add a variety of e-commerce on the web is advisable.
4. Further research should add various features to support the rice plant monitoring to develop this existing system.

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