Prototype Design of Smart System as A Vines Medium of Javanese Long Pepper (*Piper Retrofractum* Vahl)

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Abstract. Javanese long pepper is one of the Indonesia’s native medicinal plants which is included in the family Piperaceae. This plant has a characteristic thrives on plains which high rainfall between 1,200 – 3,000 mm per year and the level of soil moisture ranges from 80-100%. In the area of Bluto, Madura, these plants are generally grown on farmland by using a moringa tree as a vines medium. However, in line with technological developments, the vines media plants of Javanese long pepper begin to be replaced by technology that utilizes a concrete cylindrical as the vines media. In this research, the vines media are made from hollow concrete cylinders with a height of 180 cm which is controlled automatically by the device of Arduino Uno as a microcontroller and its connected with ultrasonic sensors, light dependent resistor sensors, soil moisture sensors, and solar cell as an alternative energy source which called smart system. It has several main functions such as medium vines of Javanese long pepper plants, keep the moisture of plants, store the water as well as being able to do the watering automatically. This prototype design is expected to be an alternative solution to improve the quality of plant growth, especially in the dry season.

1. Introduction

The event of *El Nino* is often accompanied with a prolonged dry season due to the decreased amount of rain falling in certain areas. Data reveal that there have been some cases of drought hitting 16 provinces covering 102 regencies/cities and 721 districts in Indonesia [1]. The majority of the community, especially the farmers of *Piper Retrofractum* Vahl (*Cabai Jamu / Cabai Jawa – Medicinal Pepper / Javanese Long Pepper*), feels the direct impact of the drought in the Bluto area, Sumenep regency. Javanese Long Pepper (*Piper Retrofractum* Vahl) plants can not grow well due to the decreased rainfall. Based on the background, the role of technology is considered necessary as an effort to overcome the agricultural problem of the non-optimal growth of Javanese long pepper plants in the dry season [2]. This study was aimed to install a prototype of the propagation media of Javanese long pepper (*Piper Retrofractum* Vahl) by combining several electronic and mechanical instruments including hollow concrete cylinders as the propagation medium of Javanese long pepper, and also sensors, Arduino UNO microcontroller and solar cell as the supply of energy sources that convert solar energy into electrical energy [3].

2. System Design

The *smart system* in this study used several electronic instruments such as LDR sensor (Light Dependent Resistor), ultrasonic sensor, soil moisture sensor, automatic valve, Arduino UNO, LiPo...
12V DC battery, solar cell, and IC LM3914. The electronic instruments would later be mounted on a hollow concrete cylinder with a high dimension of 180 cm serving as a propagation medium of Javanese long pepper plants. Here is a block diagram of the smart system design:

Figure 1. Block Diagram of Smart System

The ultrasonic sensor and soil moisture sensor served as input parameters on the Arduino Uno microcontroller. The ultrasonic sensor worked as the detector of water level in the concrete and gave information on the microcontroller to activate electric valve functioned as the outer wall sprayer of the concrete [4]. The soil was automatically functioned as the planting media while the soil moisture sensor was used to measure the moisture of soil as the planting medium of Javanese long pepper plants. The working principle of soil moisture sensors is to provide an output value in the form of electrical quantities as a result of water lying between the capacitor plates on the sensors. This sensor was used as the detector of soil moisture on the medium planted with Javanese long pepper so that the electric valve condition would be active (on) when the soil moisture was less than the predetermined parameter.

3. Results and Discussion
3.1 Concrete Cylinder Manufacturing
The use of a hollow concrete cylinder on the smart system has a function as a substitute for Moringa trees as the propagation medium (vine) of Javanese long pepper plants. The selection of concrete base material as the propagation medium is grounded by the fact that concrete has strong characteristic and relatively long durability (working life) without replacing the concrete. In general, the process of manufacturing concrete cylinder has several stages such as making concrete molds and concrete dough, pouring the concrete dough on the concrete molds, finishing the process, and drying the concrete. In this study, the dimension of the used concrete cylinder had a high specification of 180 cm, an inner-concrete diameter of 10 cm, and outer-concrete diameter of 14 cm.

3.2 Sensor Calibration
In this study, a calibration was needed to determine the level or range of sensor readings to be used in the system design. The calibration was aimed to produce values from the readings of the ultrasonic sensor, soil moisture sensor, and control system in the solar cell.

3.2.1. Ultrasonic Sensor
Ultrasonic sensor, in this study, was used to perform distance readings by reflecting ultrasonic waves [3]. Before it was applied to the smart system, firstly, a calibration stage must be performed to determine the reading range that would be used as a reference for the program to be created. The results obtained after the calibration were that the ultrasonic sensor readings reached 20-25 cm and 5-7 cm. The farthest reading distance of 25 was used as a reference when the system would perform water filling in the concrete cylinder by activating the electric valve, while the nearest distance of 5-7 cm was used to stop the water filling in the concrete cylinder.
3.2.2. Soil Moisture Sensor

In this study, soil moisture sensor was functioned to read the moisture level of soil used as the planting medium of Javanese long pepper plants. The purpose of the use of this sensor was to optimize the level of water use at the time of watering. When the soil moisture value was still in accordance with the parameters that had been determined, the system would not perform watering until the soil was in dry condition. In general, the way to get a calibration range of soil moisture level uses some soil samples with different humidity level, that is dry soil, moist soil, and wet soil. Based on the results of the study, there were several data ranges of the readings of soil moisture sensor as follows:

a. If (Sensor Readings ≥ 1000), the sensors could not read the level of soil moisture or in unwell-implanted condition;

b. If (600 < Sensor Readings ≤ 1000), the level of soil moisture was in dry condition;

c. If (300 < Sensor Readings ≤ 600), the level of soil moisture was in moist condition; and

d. If (Sensor Readings ≤ 300), the soil was in wet condition.

3.2.3. LDR (Light Dependent Resistor) Sensor

The smart system uses sunlight as a source of renewable energy to generate electrical energy. The working principle of solar cells is to make the absorption of electrons generated by sunlight and convert it into electrical energy which is then stored on batteries in power units. The type of battery used in this study was Lithium Polymer (LiPo) battery of 12 V DC. The factor of over load or low battery can be avoided by applying a battery monitoring system on the smart system so that the condition of the battery is expected to be steady. In this study, the battery monitoring was done analogously by IC LM3914 with the output of ten active (on) LEDs that were serialized according to the battery voltage. The output of IC would be read by the LDR (Light Dependent Resistor) sensor to make a current connection or termination. The results of battery indicator using the output of ten active (on) LEDs when the battery has 80% power or about 11.70 V.

3.3 Soil Moisture Level Control and Plant Watering Intensity Setting

This stage was done using the instrument of soil moisture sensor as the medium to monitor the soil moisture level for Javanese long pepper by performing automatic watering intensity. The program in this stage was done in line with the desired soil moisture level by using conditions (if) as the barrier between the upper and lower thresholds. The use of this condition worked until the system could distinguish the structure of dry, soil and wet soils. When the sensor readings were in the dry soil condition range, the system would automatically do watering using electric valve by activating the relay until the soil moisture sensor as wet soil condition recognized the soil condition. Figure 2 shows the condition when the system detected the dry soil condition and activated the electric valve to do the watering automatically.

The data results of this study showed that the smaller value of the ADC (Analog to Digital Converter) readings by the sensors would result in higher soil moisture level. The depth of laying sensors on the ground also greatly affected the results of sensor readings. The data of this study indicated that the ideal depth during the test process using soil moisture sensors was 4.5 cm.

3.4 Battery Monitoring System on Power Absorption Using Solar Panels
The output voltage of the solar panel system is given in Figure 3 which shows the relation between voltage to the intensity of the sunlight.

![Figure 3. Voltage output of the solar panel system](image)

Based on the testing results reveals that the output voltage of the solar panels depends on the intensity of the sunlight. The output voltage of solar cells system is increasing along with the increase in the intensity of the sunlight all day long. When the testing was done at 08.00 am, the output voltage that produced by the solar cells system reached 19.80 Volts. The largest voltage was produced at 13.00 pm which reached 21 Volts because it was the peak time of the sunlight intensity. When the testing was performed at 16.00 pm, the output voltage was the lowest condition because its indicated that the sunlight intensity was reduced significantly.

Based on the results of the study, it was obtained that the smart system could make a performance according to what was desired. The system could terminate the current when the battery was full and conducted a current connection when the battery condition was critical. This proved that the monitoring of voltage capacity worked well. IC LM3914 displayed a level indicator of battery voltage with the output of ten active (on) LEDs serially according to the state of the 12 Volt DC battery voltage. In the charging process carried out from the state of the 11.70-volt battery to the full state of 12.60-volt battery took time for about 3 hours depending on the high intensity of irradiation of sunlight. The charging from the solar panel had a relatively long span of time because the flowed currents had a small amperage of 500-800 mAh.

3.5 Overall System Design

The assembly of electronic and mechanical instruments on the smart system is shown in Figure 4.

![Figure 4. Assembly on Smart System](image)

In general, the working principle of this system is to drain the water that has been stored in a reservoir into the concrete cylinder as well as to automatically water the bottom and middle parts of the concrete cylinder by setting the electric valve instrument. When the water level in the concrete cylinder was reduced in a certain height, the water inside the reservoir would automatically fill the concrete cylinder. The water inside the cylinder would sleep out and moisten the outer surface/wall of the concrete cylinder. This moist concrete cylinder medium would be used as the propagation medium
of Javanese long pepper. The main energy used as the power source of the smart system was obtained from solar energy converted by solar cell devices to become DC electrical energy.

4. Conclusion

Smart system is a multi-functional and environmentally friendly technology that aims to store and conserve water usage, control water level, maintain soil moisture, perform watering automatically and utilize renewable energy from sunlight as the main power supply. This system consists of several electronic and mechanical devices such as a concrete cylinder used as the propagation medium of Javanese long pepper, LDR (Light Dependent Resistor) sensor, ultrasonic sensor, soil moisture sensor, automatic valve, Arduino UNO, 12V DC LiPo battery, solar cells, and IC LM3914.

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