Solar-Powered Precision Irrigation System for Palm-Oil Pre-Nursery Plantation

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ABSTRACT: This paper proposes a design of a precision irrigation system powered by solar energy for palm-oil seedlings growth. This is a pilot system that will be implemented in a full-scale palm-oil pre-nursery at the estate belongs to YP Plantation Holdings Sdn. Bhd. in Rompin, Pahang. The precision irrigation system which uses a water dripping technique irrigates the seedling in each of the trays directly, controlled by a microcontroller with a timer and soil moisture sensors as monitoring functions. The components used in the proposed system are powered by solar energy to give access to electricity in rural areas. From the results, the proposed system managed to reduce the water wastage to 30% compared to the manual watering system and monitor the moisture content needed by the palm-oil seedlings.

Keywords: *Solar-powered; Precision Irrigation; Palm-oil.*

1. INTRODUCTION

Precision irrigation becomes an efficient system in managing water resources to maintain productivity in agriculture. This technology could help farmers and planters to manage water usage more efficiently and avoid water wastage. By designing an efficient and precise irrigation system, it would help in boosting crop yields, reduce cost, and support environmental sustainability [1]. Conventional irrigation systems in a palm-oil nursery is mostly using a sprinkler system that has disadvantages in water wastage and a high possibility the seedlings did not obtain enough moisture for optimal growth [2], [3]. With the advancement of affordable microcontrollers and wireless sensors, precision irrigation could be designed based on the requirement of the plants and supply data that is needed by the farmers to observe the growth of the plants.

Precision irrigation in agriculture also deploys Internet-of-Things (IoT) technologies in transmitting the data collected from the wireless sensor network at the farm. The collected data could be the parameters involved in plants health such as temperature, soil pH level, soil moisture level and others which then are analysed to produce agronomic recommendations [4].

Most of the irrigation system is powered using fossil fuel-based water pumping system which causes damage to the environment. Therefore, renewable energy such as solar energy could be used as an electricity supply to power the components used in the precision irrigation system [5].

This study proposes a design in precision irrigation that uses a dripping watering method for each palm-oil seedling and with help of a microcontroller to automatically control the water flow using a solenoid valve and timer control relay. This method later could be improved by implementing more intelligent methods in scheduling and decision-making of the actuation units in precision irrigation.

2. METHODOLOGY

In this paper, we propose an irrigation system for palm-oil seedling watering that is powered by solar power and controlled by a microcontroller with wireless sensor nodes as monitoring features. The objective of this study is to develop a system in managing water usage automatically at the pre-nursery as well as to monitor the soil condition used in growing the palm-oil seedlings.

The proposed solar precision irrigation system is divided into five units which are the solar panel as power supply, the processing unit as the brain of the proposed system, the actuation unit to control the flow of the water into the pre-nursery, the sensing unit that has several wireless sensor nodes and subscriber unit as the platform for monitoring the whole system.

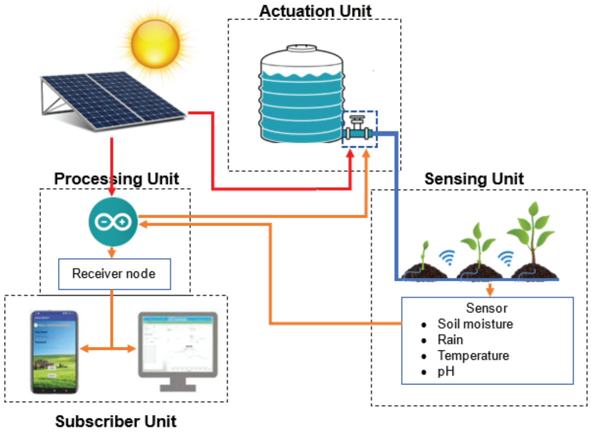

Figure 1 System Block Diagram

The condition of the irrigation system control using a microcontroller, a timer control relay and a valve relay was tested and displayed using serial monitor display on Arduino IDE. The system was tested to switch on and off the valve in a real-time setting and ran for 10 minutes. Therefore, when the time passed 10 minutes, the irrigation stopped when the water valve received a signal from the microcontroller for the water valve to switch off.

After installations of the irrigation system control, water flow monitoring and the solar system, we ran tests to observe the performance of the proposed system. We held the test twice; the first test is when the drip tapes do not contain any water and the condition of the medium is dry. The same test was held again where the drip tapes had already contained water from the previous test and the medium was moist.

3. RESULTS & DISCUSSION

The result of the tests is shown in Table 1. From this table, we observe the water volume, water flow rate and time taken for the water to reach the last hole when it dripped onto the rain sensor located below the hole. In Table 2, we collected numerical readings on the soil moisture sensors located at 3 different points in the pre-nursery.

Table 1 The data collected on water volume, flowrate and time taken for the water to reach the rain sensor.

Test No.	Water Volume (L)	Flowrate (L/min)	Time taken to reach rain sensor (minute)
1	55.5	5.55	7
2	57.5	5.73	7

Table 2 The data are taken from 3 soil moisture sensors on 3 different locations at the watering tray.

Test No.	Soil Moisture Sensors					
	A1 (end)		A2 (middle)		A3 (front)	
	Dry	Moist	Dry	Moist	Dry	Moist
1	975	621	974	739	975	776
2	775	667	785	714	761	690

The readings of these soil moisture changes during the watering period are recorded and converted into a graph illustrated in Figure 2. This figure showed that all three sensors were working as expected in obtaining the moisture of the medium inside the watering tray.

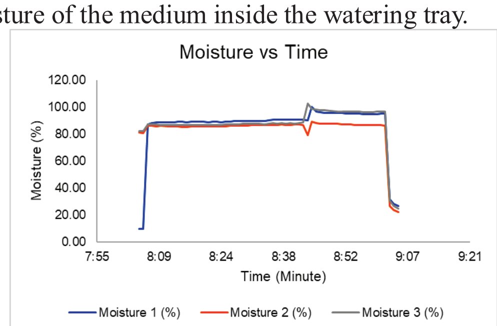

Figure 2 Moisture of the soil during the irrigation on morning session using 3 soil moisture sensors.

However, more tests need to be conducted to observe any abnormality in the system and modifications have to be done in improving the performance of the proposed system, especially the water flowrate. These test results later need to be compared with the performance at the real site that is currently operated manually. Currently, the real site let the water flow for 10 minutes thus caused the water wastage at the nursery. Based on this study, the water wastage could be avoided if this system is deployed. From our finding, the pre-nursery only needs 7 minutes for the water to be distributed to all palm-oil seedlings instead of 10 minutes.

4. CONCLUSION

This paper illustrated a brief design of a solar irrigation system using a time relay and wireless sensor nodes powered by solar energy. The system was successfully tested and functioned as expected, with minor improvements to be made in the scheduling system and the development of the subscriber or display unit. The system could help manage the water usage at the pre-nursery automatically and monitor the moisture content needed by the seedlings which is crucial in its growth to produce high quality yield. Other issues such as power distribution, sensor nodes management and performance of data transmission will have to be extensively studied and evaluated.

ACKNOWLEDGEMENT

The authors would like to thank the Ministry of Higher Education for providing financial support under the Malaysian Technical University Network (MTUN) Industry Matching Research Grant (Universiti Reference RDU212801), Universiti Malaysia Pahang for laboratory facilities and YP Plantation Holdings Sdn Bhd Pahang as the collaborator with additional financial support under Industrial Research Grant (University Reference UIC210805).

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