

Smart Cocoa Nursery Monitoring System Using IoT for Automatic Drip Irrigation

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Abstract— Conventional agriculture systems normally ineffective and consume a lot of manpower and water resources. In this project, an automatic drip irrigation system based on IOT platform is designed. This system is implemented in cocoa nursery at Malaysian Cocoa (MCB) Bagan Datoh. Smart Cocoa Monitoring System Using IoT for Automatic Drip Irrigation is designed by creating optimal soil moisture conditions to facilitate healthy plant growth through proper irrigation frequencies. With a Raspberry Pi 3 Model B, the user can monitor the soil moisture in the cocoa plant nursery and the irrigation machine through the network. Therefore, to monitor the environment for this agriculture, the system will collect the information of the soil moisture. Any changes detected by the built-in sensors of the system that can harm the cocoa plant nursery will be noted and the system will provide soil moisture information and can be monitored through ThinkSpeak.com application for further action to be taken. To monitor the efficiency of the system, the height of each cocoa plant (cm) and the number of leaves per cocoa plant is observed within 3 weeks. For comparison, this monitoring system that controlled by a Raspberry Pi3 model B with drip irrigation technique is recorded as Treatment 1 (T1) and the overhead sprinkler technique that has been applied in MCB, Bagan Datoh, Perak is recorded as Treatment 2 (T2). It is observed that the percentage height of coco plant based on T1 is increased by 26.82% while T2 only 16.04%. The percentage increment of leaves based on T1 is 36.31% while T2 is 20.70%.

Keywords— *Drip Irrigation; Cocoa Nursery; Raspberry Pi3 Model B; Soil Moisture Sensor; IoT-Based Monitoring System*

I. INTRODUCTION

Plant nursery is defined as an area where plants are raised for ultimate planting out. For cocoa plant, nursery classified as a first stage of plant by germinated the seed into polybag before the process of transplanting cocoa plants to the plantation at the suitable age has. Normally, cocoa seedlings will be in the nursery for 4 until 6 months before being transferred to the plantation.

Conventional agricultural irrigation technique that used in cocoa plant nursery is often inefficient to crop yield and widely used human resources and water resources. Given that conventional agriculture exists numerous issues as of now, for example, low usage of water and manure water system [1]. Regular farming is gradually changed into computerized agriculture specifically as Precision Agriculture (PA). In turn, this results in less wasted water, seed, fertilizer, fuel, and time.

It is intended to provide a source of water and fertilizer manually by farmer. It also carried out by following the time schedule set for the plants in the nursery. The traditional agricultural system will face the problem of improving the quality of the plant consistently. This conventional kind of cultivating is characterized by a constrained access to the household markets and by a low level of innovation [2].

Fig. 1 shows sprinkler technique for irrigation system used in cocoa plant nursery. The maximum sprinkler yield will decide the length of sprinkling does not exceed more than 9 litres of water per minute and a likeness 15 mm or less is for the most part sufficient [3]. In any case, the rates should to be checked by analysing the soil moisture substance of the potting media. Appropriation of the sprinkler framework should to be consistently checked to guarantee notwithstanding watering. This conventional agriculture watering system regularly wasteful and expend a considerable measure of men power and water resources. Therefore, the development of monitoring system serves as one of the water control techniques for the purpose of saving in terms of water usage [4].

These systems convey water to crops by shooting it out of sprinkler heads high into the air, where it would then be able to tumble down onto the plants [5]. This technique is preferred by a few, with the reason that the sprinkler framework mirrors normal precipitation and drenches the grass, or garden, totally. No piece of the plant is unreached by the sprinkler framework [3]. Although this strategy is best to mimic regular precipitation, it has its downsides. On breezy or incredibly hot days, some water will be lost. In high breezes, water will be overwhelmed from plant people, and on hot days, a rate will essentially vanish before achieving the ground [5].

Precision Agriculture (PA) is where the rancher ready to get to parameters identified with his homestead and ready to control the related parameters either physically, in plan or consequently. In Precision Agriculture (PA), one of the imperative sensors is soil moisture sensor. This sensor would give level of water in the soil. Level of water for yields is dictated by agronomist [6]. Considering the water level feedback system will enable to know how much water need to flood the products. An excessive amount of water in the soil would influence the use of nitrogen of the roots. In the meantime, the oxygen at the roots will be inadequate. Each kind of yields would require different level of water.

Accordingly, level of water demonstrate by dampness would be diverse rely upon the kind of yields [7].



Fig. 1. Sprinkler technique applied in cocoa nursery at Malaysian Cocoa Board, Bagan Datuk, Perak

Currently, this system is working based on drip irrigation technique. The drip irrigation technique is different from the sprinkler technique, as it conveys water specifically to the soil, leaving stems, leaves, and other foliage totally dry. Drip irrigation technique is an extraordinary on the grounds that it enables each drop of water to advance toward the root zone [8]. In this technique, the water is provided to the root zone of cocoa plant drip by drip and helps to reduce large amount of water used [8]. Water is valuable to every one of the people and additionally to the plants. The real measure of crisp water is used by the horticultural business for water system. By utilizing drip irrigation technique, the water will be kept up at the consistent level for instance the water will achieve the roots by going drop by drop [5]. This is critical on the grounds that this can just guarantee the survival of the plants [9].

Soil moisture condition is exceptionally fundamental for the development of cocoa plants particularly in nursery organize. The most ideal soil moisture condition for germination phase of cocoa plant ranged between 50 % to 70 % unit of soil. With the development of society, traditional forms of agriculture cannot satisfy people's needs, so agriculture must be change to satisfy people needs [10].

In addition, water is the most bounteous material in a developing plant. Water disintegrates the soil minerals which are fundamental to plant development and the significant piece of plant supplements are accepted to be taken into the plant while they are in arrangement. Water traveling through the soil plays out a capacity in the flushing of pore spaces. As water moves descending in the soil it replaces the gases, for example, carbon dioxide, which possess pore spaces and as the water depletes out of soil more air is attracted. Consequently it helps in gas trade and in carrying oxygen into the root condition [11].

Accordingly, watering is maybe the most imperative single necessity in a polybag nursery. In any case, finished watering particularly in the initial 2-3 months should to be maintained a strategic distance from as the youthful cocoa seedling is amazingly touchy to waterlogging. Watering once every day with $\frac{1}{2}$ to $\frac{3}{4}$ litres of water per seedling is for the most part enough. Nonetheless, the right rates might be controlled by checking the moisture substance of the preparing media and need to guarantee that moist at the top and bottom of the sack. Rancher needs to expand the rate if the soil is dry and pull back or diminish the rate on the off chance that it is excessively wet. During unusually long spells

of dry climate, it might be important to water the seedlings two times per day.

Generally, the quality of plant is also affecting the crop of yields including small size of cocoa beans and it will affect commercial produce. Little scale agriculture in Southeast Asia has constantly changed because of changing conditions as the years progressed, yet there is boundless understanding that change will be especially fast amid the coming decades. Changes in tropical agriculture have been especially fast amid the previous century under the effect of imperialism and different types of contact with western culture and innovation, yet the pace of progress has stimulated considerably additionally amid the previous couple of decades with regards to a universal improvement exertion went for expanding worldwide sustenance generation [12].

This proposed system is implementing the technology of monitoring system which allows electronics and software programming within a product. The input and output interfaces can be easily installed and can be used by everyone since it is very handy and user friendly. Furthermore, the advantage of this technique is that farmer can control drip irrigation from anywhere and at any time. Thus, the monitoring system using irrigation for cocoa nursery is a system that acts as a device that can sense and indicate the changes to the soil in cocoa plant nursery area which may affect the plant and its activity. Those changes are sending through wireless sensor network so that the information can reach the user by using smart phone or computer monitoring. This system must keep the soil moisture at a suitable condition for the agricultural activities and soil moisture sensors are used in this system as a medium for identifying soil conditions whether it is suitable for the plant or not [6].

II. METHODOLOGY

A. Block Diagram

Fig. 2 shows the project implementation with Raspberry Pi3 model B act as a microcontroller and a soil moisture sensor as the input. This soil moisture detects the optimum moisture condition. The solenoid valve will operate when the soil need water. Then, data will be collected and will be displayed through ThingSpeak.com application for monitoring purpose.

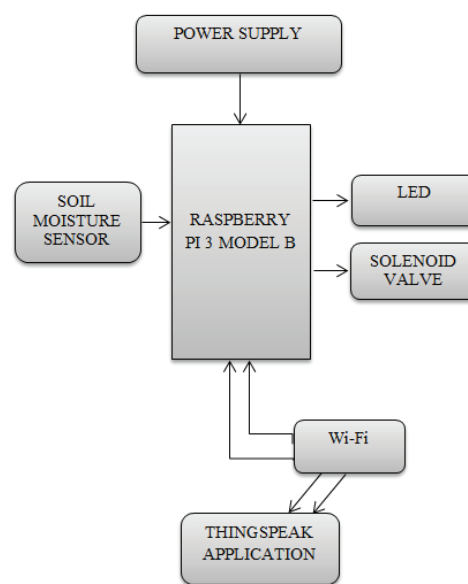


Fig. 2. Block Diagram

A. Project Flowchart

Fig. 3 below shows the flowchart of the monitoring system. Firstly, the system will make sure whether the device has been connected to the smart phone or any device through WiFi. When those two mediums have been connected to each other, the device will start to detect any changes which will be measure by the soil moisture sensors that monitor the changes in the soil moisture condition. The LED will indicate the level of the soil moisture. The outputs will be triggered when the condition is not at its optimum level.

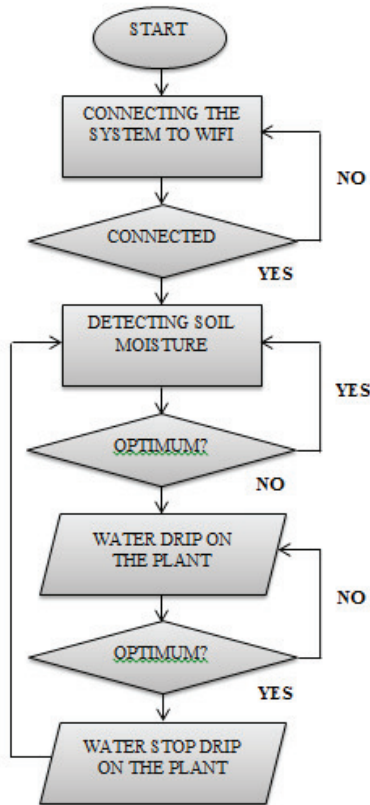


Fig. 3. Project Flowchart

B. Hardware Implementation

Based on the Fig. 4 below shows a Raspberry Pi 3 Model B is the third generation Raspberry Pi. This powerful single board computer can be used for many applications. It is more powerful processor, 10 times faster than the first generation of Raspberry Pi. Additionally, it adds wireless LAN & Bluetooth connectivity to make it the ideal solution for powerful connected designs. So, this is more suitable and stable for a monitoring system applied in cocoa nursery.

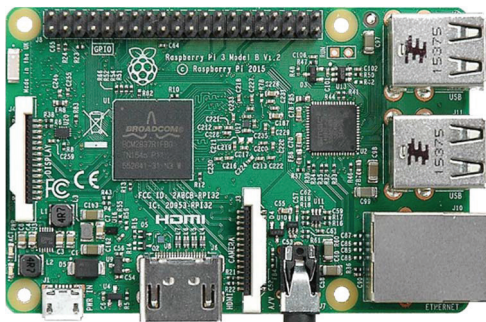


Fig. 4. Raspberry Pi3 model B

This Fig. 5 shows a liquid valve would make a great addition to an agriculture monitoring system. There are two 1/2" (Nominal non-taped National Pipe) outlets. Normally, the valve is closed. When 12VDC is applied to the two terminals, the valve opens, and water can push through. The valve has a gasket arrangement inside, so there is a minimum pressure requirement of 0.02Mpa (3 PSI). Also, liquid can only flow one direction.



Fig. 5. Solenoid valve

Based on Fig. 6, this soil moisture sensor FC-28 is measure the volumetric content of water inside the soil and gives us the moisture level as output. This Moisture Sensor can read the amount of moisture present in the soil surrounding it. With analogue pinout will give data reading through an MCP3008 stated as an Analog Digital Converter (ADC).

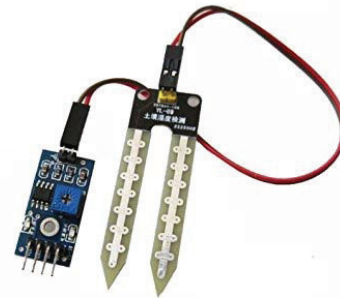


Fig. 6. Soil moisture sensor FC-28

III. RESULT AND DISCUSSION

The result of this project aims to produce a monitoring system that can control soil moisture conditions in optimum conditions to periodically monitor the growth precision of cocoa plants at nursery sites with drip irrigation techniques. The capability to document and detail changes in parameters of interest has become increasingly valuable. The smart phone acts as a monitoring system using Wi-Fi and will help the landlord plantation to monitor and manage their status of their plantation for cocoa plant in nursery to increase the production and improvement of quality at various agriculture sites. This monitoring system in the cocoa nursery is not only to reduce the human power, but it also allows user to see accurate changes of the environment parameters.

Fig. 7 below shows the application of agriculture monitoring system that controlled by Raspberry Pi3 model B and this considered as a low cost and reliable system which is considered as Treatment 1 in this project.



Fig. 7. Treatment 1(T1) is a drip irrigation system controlled by using Raspberry Pi as microcontroller applied in cocoa nursery of Malaysian Cocoa Board (MCB), Bagan Datuk, Perak

Fig. 8 below shows the overhead sprinkler technique that applied in cocoa nursery which is considered as Treatment 2 in this project.



Fig. 8. Treatment 2(T2) is an overhead sprinkler system in cocoa nursery of Malaysian Cocoa Board (MCB), Bagan Datuk, Perak

Fig. 9 below shows the soil moisture sensor was connected to GPIO pin of Raspberry pi3 model B that act as a microcontroller will produce soil moisture reading. Any changes detected by the sensors will be processed. The information is then sending over the Wi-Fi and directly to the user.

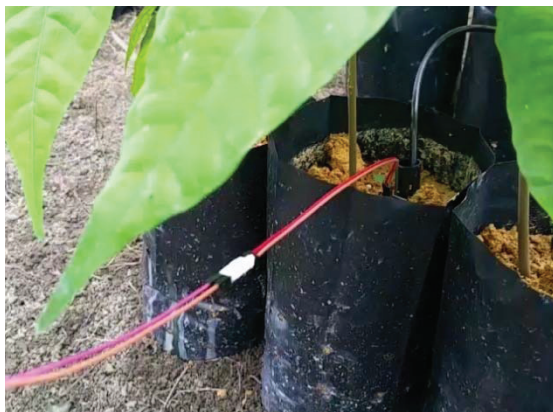


Fig. 9. Soil moisture sensor gives moisture data to control the solenoid valve

Thus, soil moisture sensor gives the actual reading to ensure the cocoa plant in the nursery get the optimum level of water needed. All data from the sensor readings will be collected and will be compared to the sensor readings daily for a month. Data reading on hot days and rainy days will also be comparable to ensuring the sensors work well. Additionally, daily readings of soil moisture data recorded

into ThingSpeak.com application to ensure that the sensor's sensitivity still in a good condition.

Based on the observation in Fig. 10, the soil moisture condition on the afternoon is not in the optimum level of soil moisture condition compared to soil moisture condition on the evening is at the optimum level that shows in Fig. 11. Based on the sensor readings, if soil moisture condition is not in the optimum level for the cocoa plant, the user can see that the drip irrigation automatically switched on to make sure the parameter remain at its optimum level and user can monitor the data all from the smartphone through ThingSpeak.com application.

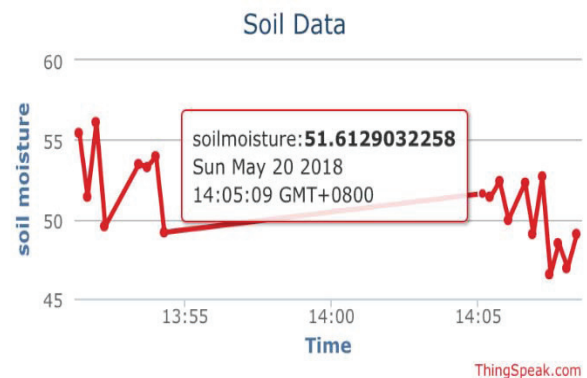


Fig. 10. The reading of data on the afternoon in range 46% to 56% of soil moisture before the solenoid valve operate

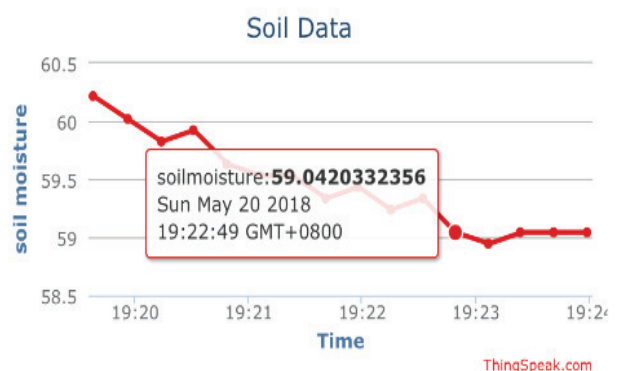


Fig. 11. The reading of data on the evening in range 58.9% to 60.2% of soil moisture after the solenoid valve operate

Fig. 12 shows that the reading of the soil moisture condition during rainy day. During rainy day, the solenoid valve did not operates because of he soil moisture condition is on the optimum level.

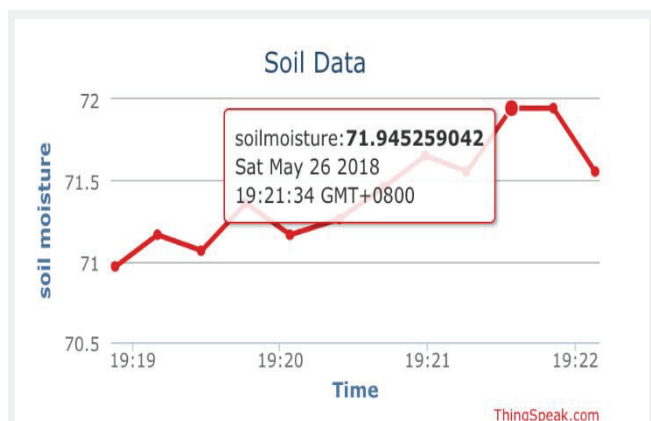


Fig. 12. The readig of the data on rainy day in range 71% until 72% of soil moisture witout any operation from solenoid valve

In this project, 30 seedlings had been controlled and monitor by automatic drip irrigation technique with soil moisture sensor (T1: Treatment 1) and 30 other seedlings will be controlled and monitor by Malaysian Cocoa Board's existing technology which is by using sprinkler technique (T2: Treatment 2). The ages of all seedlings taken to extend the observations for Treatment 1 and Treatment 2 are approximately one month old. Then the plant in cocoa nursery analysed within 4 weeks of planting in the nursery to see the comparison between this automatic drip irrigation system and the existing technology in Malaysian Cocoa Board. Apart from the germination of cocoa plants age on first week of the experiment are the same, the lighting rates and fertilizer content given twice for a week are also the same on both Treatment 1 and Treatment 2. Black net is used to allows sunlight to pass through it is 70 percent. For the fertilizer, Nitrophoska Blue TE fertilizer is used and the quantity of fertilizers given at each Treatment 1 and Treatment 2 is the same in range 5gram up to 10gram per plant. This type of fertilizer contains 12:12:17:2+8S which are 12% of nitrogen, 12% of water-soluble phosphorus, 17% of water-soluble potassium oxide, 2% of water-soluble magnesium oxide and 8% of water-soluble sulphur. The comparisons will be finished by observing the height and the number of leaves of cocoa plant. The leaves' length is recorded if measured exceeding 10 centimetres (cm). All the data recorded every 1 week within 3 weeks of observations.

Table 1 shows the data of increment of height and number of leaves of each cocoa plant in percent. Treatment 1 stated the drip irrigation technique by applying raspberry pi as microcontroller while Treatment 2 stated of using sprinkler technique in cocoa nursery of Malaysian Cocoa Board, Bagan Datoh , Perak.

TABLE I. PERCENTAGE INCREMENT OF HEIGHT AND NUMBER OF LEAVES

	Increment of height (%)		Increment number of leaves (%)	
Total mean	(T1)	(T2)	(T1)	(T2)
1 st week	6.62	4.5	9.78	6.28
2 nd week	9.24	6.65	12.03	9.58
3 rd week	10.96	4.89	14.50	4.84
Total	26.82	16.04	36.31	20.70

Based on the increment of height data in Fig. 13 below, it shows that data on Treatment 1 is more effective than Treatment 2. Thus, the length of time taken by Treatment 1 to reach a height level is much faster than Treatment 2.

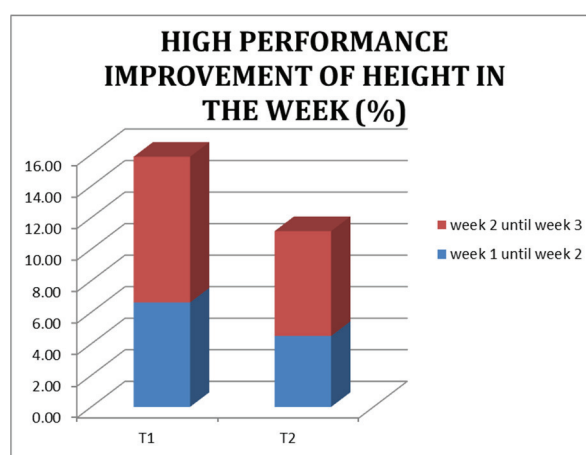


Fig. 13. The improvement of height in centimeter (cm) between T1: Treatment 1 and T2: Treatment 2 within the weeks

Based on the increment of height data in Fig. 14 below, it shows that data on Treatment 1 also is more effective than Treatment 2. Thus, the length of time taken by Treatment 1 in the scope of leaf growth is faster than Treatment 2.

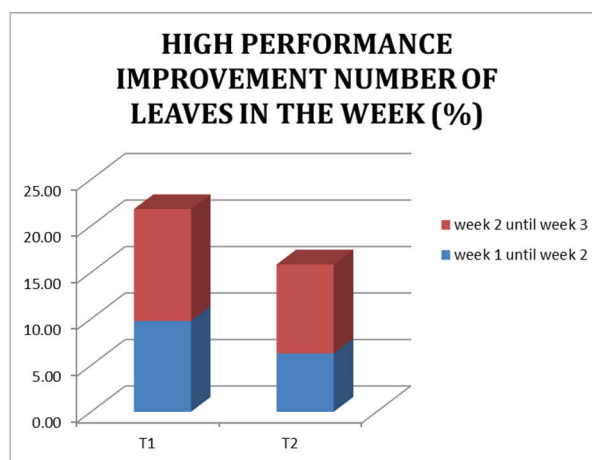


Fig. 14. The improvement the number of between T1: Treatment 1 and T2: Treatment 2 within the weeks

IV. CONCLUSIONS

The “Development of Monitoring System in Precise Cocoa Nursery by applying Automatic Drip Irrigation” which is an application system of wireless sensor technologies in agriculture and food industry is current trend application system. This makes it possible to increase efficiencies and productivity of plantation. The system can provide a device that help to monitor the cocoa nursery soil moisture environment at all time. Based on functions of this application system, it could help an industry to minimize cost by lowering the need of manpower and also helps to improve the quality of plantations in the agriculture field by supporting the decision making of producers through the analysis of the collected information. These approaches have been proved to be an alternative way to replace the conventional method that use men force to monitor the environment and improves the performance, robustness, and provides efficiency in the monitoring system. Here, this application system is proposed to maintain the production of food in an industry.

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