DEVELOPMENT OF PRECISION IRRIGATION SYSTEM FOR DURIAN TREE BASED ON REAL TIME SOIL MOISTURE READING

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A report submitted
in partial fulfillment of the requirements for the degree of
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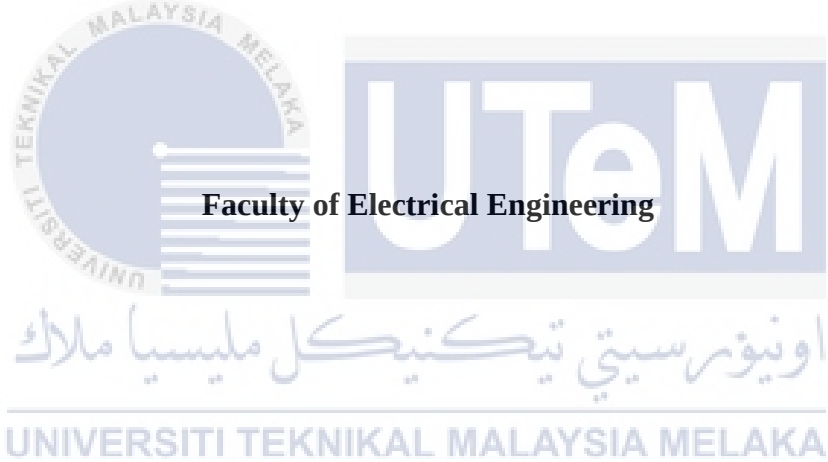

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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DECLARATION

I declare that this thesis entitled "DEVELOPMENT OF PRECISION IRRIGATION SYSTEM FOR DURIAN TREE BASED ON REAL TIME SOIL MOISTURE READING is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Date : 5/7/2021

APPROVAL

I hereby declare that I have checked this report entitled "DEVELOPMENT OF PRECISION IRRIGATION SYSTEM FOR DURIAN TREES BASED ON REAL TIME SOIL MOISTURE READINGS" and in my opinion, this thesis it complies the partial fulfillment for awarding the award of the degree of Bachelor of Mechatronics Engineering with Honours

Signature : .....

Supervisor Name : NUR LATIF AZYZE BIN MOHD SHAARI AZYZE

Date : 5 JULY 2021

DEDICATIONS

To my beloved mother, Pearl Sheila and father, John Selvin, my brother, Joshua and sister, Lynliana for their encouragement and support.

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ABSTRACT

Irrigation is an essential system for farms as it allows for the trees to receive water to grow. However, t danhe problems of most durian farms according to reports are that the farmers lack understanding of the sprinkler irrigation and poor farming practices that lead to potential death of durian trees, excessive water usage and lack of technology. Therefore, the objectives of this report is to develop and enable IoT a sub-surface irrigation system that will be actuated based on capacitive soil moisture sensor, to analyse the stability of the soil moisture sensor and lastly to analyse the precision of the sub-surface irrigation system with respect to the soil moisture threshold. The experiments to fulfill the objectives are callibration of capacitive soil moisture sensor with respect to increments of water by fixed volumes and reading the voltage from the NodeMCU. An IoT network was set up using NodeRed and FavorIoT to enable 2 way communicate with the NodeMCU. Lastly, the sub-surface irrigation system was tested by channeling water to the sensor with two cases, that is, one without a funnel, and one with a funnel to guide the water to the base of the sensor. The results show that the sensor gives a 100% soil moisture at 260ml based on a 400ml of soil.The IoT platform can function. Lastly, the sub-surface irrigation with the funnel's relative error was calculated and the maximum error obtained was 13% and the minimum error obtained was 2%. As a conclusion, the sub-surface irrigation with IoT enabled can work and provide data over long term periods and easy methods of actuation. Next, the sensor is proven to be stable. Lastly, the precision of the sub-surface irrigation is relatively high.

ABSTRAK

Sistem pengairan adalah satu keperluan untuk ladang untuk perairan dan tumbuhan pokok. Walaubagaimanapun, masalah dengan kebanyakan ladang durian berdasarkan laporan adalah petani yang kurang memahami cara sistem pengairan percik dan amalan pertanian yang tidak betul boleh menyebabkan potensi kematian pokok, penggunaan air yang keterlaluan, dan kekurangan penggunaan teknologi. Oleh itu, objektif projek ini adalah untuk mengembang dan mengaktifkan penggunaan IoT dalam satu sistem pengairan bawah tanah yang berfungsi dengan sensor kelembapan tanah kapasitif, menganilisis kestabilan sensor kelembapan tanah kapasitif dan menganalisis ketetapan sistem pengairan bawah tanah berdasarkan tahap kelembapan tanah. Eksperimen yang dibuat untuk menjayakan objektif objektif tersbut adalah dengan pertamanya, menentukur sensor kelembapan sensor kapasitif dengan mendapat bacaan voltage daripada NodeMCU berdasarkan penambahan air secara bertahap. Satu rangkaian IoT dibentuk dengan NodeRed dan FavorIoT untuk mengaktifkan komunikasi dua hala antara NodeMCU. Akhir sekali, sistem pengairan bawah – tanah dilakukan dengan dengan 2 kes, satu adalah tanpa corong dan satu kes dengan corong untuk menyasarkan sensor. Hasil daripada eksperimen adalah sensor memberi bacaan 100% kelembapan tanah dengan 260 ml di dalam bekas berdasarkan 400 ml isipadu tanah yang digunakan.Seterusnya, platform IoT boleh berfungsi. Seterusnya, Stabiliti sensor dibuktikan daripada bacaan sensor selama 5 minit dan juga corak graf yang didapati daripada FavorIoT. Akhir sekali, keslahan relatif sistem pengairan bawah tanah maksimum adalah 13.33% dan minimum adalah 2%. Kesimpulannya, sistem pengairan bawah tanah dilengkap dengan IoT boleh berfungsi dan memberi bacaan masa jangka panjang dan senang untuk diaktifkan. Seterusnya, sensor adalah stabil. Akhir sekali, ketepatan sistem pengairan adalah tinggi secara relatif.

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IoT	-	Internet of Things
MQTT	-	Mass Queue Telemetry Transport

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INTRODUCTION

CHAPTER 1

1.1 Background

Durian, also known by its scientific name, Durio Zibethinus, is an iconic tropical fruit plant that is mainly cultivated in Malaysia and the Southeast Asian countries. It is also referred to its title as the King of Fruits. According to the study of Mardi in 1991 [1], titled "A review on the nutrition on the nutritional, medicinal, molecular and genome attributes of Durian", the Durian's name originates from the Malay word 'Duri', meaning thorns. As for the scientific name, Zibethinus, based on the name of a large Indian Civet, a feline species known for its smell. Other names have followed such as "civet fruit" in India, "Stinkfrucht" in German and "Stinkvrucht" in Dutch. Each durian tree produces 15 – 800 fruits every fruiting season. The general weight of the fruit ranges from 1 kg to 3 kg in size.

According to a news report by Al-Jazeera [2], the best durians fortunately come from Malaysia, among the other South East Asian countries that are capable of growing durians. Recently, China has been slowly increasing their taste for durians from the recent years as a report of an increase of durian consumption from 2006 to 2016 increased at 13%. In another news article written by Khor Reports [3], China is expecting to import USD120 million from Malaysia in durians every year, amounting to about 23% of Malaysia's output of premium grade durians. In terms of weight that would be about 75 000 tons to China. Therefore, the reason to optimize Durian yield proves a challenge.

In line with the current Industrial Revolution 4.0, has incurred a large boom or expansion in the application of wireless technology, AI and other features into everyday life. The insertion of this technology into farming has been given many terms

and among it is Agriculture 4.0. According to [4], the incentive to push and innovate agritech in Malaysia has been done to grow and develop the sector in Malaysia.

1.2 Objectives

1. To develop and enable IoT a sub-surface irrigation system that will be actuated based on capacitive soil moisture sensor.
2. To analyse the stability of the capacitive soil moisture sensor.
3. To analyse the precision of the sub-surface irrigation system with respect to the soil moisture threshold.

1.3 Problem Statement

According to [5] poor farming practices is one of the risks of agricultural practices in Malaysia, under the section of water management, that an upgrade for water management is necessary due to the excessive usage of water especially during irrigation. In line with this water management issue, a research done pertaining to water management of durian farms in [6] suggested that most farmers lack knowledge about irrigation, primarily sprinkler irrigation. Based on the literature found in [1,7,8], it is known that sprinkler irrigation is one of the conventional means of irrigation. Durian trees are known to be sensitive to water. To begin the fruiting season, a certain amount of drought condition must be met for about 4 weeks. Once this is achieved, the flower buds will begin to show as pimple like structures, to which moderate amounts of irrigation is required. Once, the flowers have opened and bloom, the tree will require more water to be irrigated.

1.4 Motivation

Based on the problem statement, the motivation of this research is to benefit the improvement of water management and quality of yield, specifically durian trees by creating a design of a sub-surface irrigation that will be actuated based on using soil sensing technology such as the capacitive soil moisture sensor in real time. Next, the enabling of IoT control will also allow for the evolution of farms in Malaysia, as

mentioned by [5], that for now seems to be lacking. Based on some literature like [1,7,8], the volume of water used for irrigation is set to their own choices, such as 75 liters per day, 150 liters per day and with the success of this report, the amount of water required can be regulated and potentially save costs. Without proper management of water intake, sprinklers may excessive water to the tree, sometimes the water may stagnate at the roots of the tree and can cause root rot [5]. The figure down below shows a picture of the root rot occuring.

Figure 1-1:Durian tree experiencing root rot due to excessive watering [5].

1.5 Thesis outline

Chapter 2 discusses a lot of the details that would provide insight to the completion of this project by referring to past studies, journals, articles and component datasheets to give insight to how similar research and projects were performed prior to this project.

Chapter 3 discusses about the methodology of this project, project flowcharts, gantt charts showing the progress and steps to finish this project, discussion of components and their functions in this project. Parameters to be analysed in the results, experimental set-ups nd procedures and their limitations.

Chapter 4 shows the results obtained from the experiments that were performed and discussion about the results to provide details on how the results come as such. Lastly, analysis were done on those results to validate the objectives of this project.

Chapter 5 concludes the results obtained from the experiments performed and also presents possible future works to further improve this project.

1.6 Scope

The scope of this research is only to the actuation of the sub – surface irrigation that will be based on the soil moisture sensor and no other sensor like ambient temperature and pressure sensors, and NPK (Nitrogen Phosphorus Potassium) sensors. Next due to the pandemic, a weighing scale could not be obtained to perform better and more accurate soil moisture sensor calibration. The type of soil used for this experiment is also a different kind of soil, not the clay loam soil that is used by most durian farms. Lastly, the IoT enabling will be done by using NodeRed, FavorIoT and a Telegram bot that allows the use of controlling and monitoring the soil moisture conditions remotely. With the lack of certain equipment and tools, only simple analyses can be done such as the stability of the sensor and also the ability of the sub-surface irrigation to maintain the moisture at the threshold every time irrigation is carried out.

LITERATURE REVIEW

CHAPTER 2

2.1 Introduction

In the literature review, the literature found will be segmented according to the requirements of the durian tree, for example suitable conditions for durian growth, root activity, types of irrigation systems, soil moisture sensors and lastly the MQTT protocol. The reason all of this is necessary is to enable this project to create an irrigation system that can measure the soil moisture of the roots where the activity is the highest to enable the irrigation system to target specifically those root zones and also adhere to the proper requirements of the tree relative to its phase and include IoT applications allowing for the monitoring and control of the irrigation system remotely.

2.2 Suitable conditions for durian growth

In a study titled "The Durian: Botany, Horticulture, and Utilization", the suitable planting conditions, followed by watering conditions as well as the ideal irrigation was researched and studied. The durians are best planted in deep fertile soil, or clay loam with good drainage and high organic matter. This is because of the presence of Phytophtora, which can induce root rot. Water that does not drain and is stagnant in the soil can favour the growth of pathogenic organisms. It is advisable to account for the presence of phytophtora spp. There are multiple test kits that can perform rapid testing and can be purchased online but it will not be covered in this research. The irrigation conditions mentioned that there were significant growth differences present between irrigated trees and the non – irrigated trees. Throughout the growing phase of the Durian trees, irrigation must be either done for long periods of time or rather short intervals depending on the growth phase to avoid unnecessary damage to the tree which is referred to as water stress that can prove fatal and wasteful.[1]

This is confirmed by [7] which mentioned that the durian was sensitive to water stress. The results obtained was conducted from the year 1992 to 1995 in a durian Orchard at MARDI in agro-ecological zone 4 in Seberang Perai. Zone 4 experienced 3 months of draught and 1 month of excessive raining. Jaafar's results mentioned that the water treatments influenced the growth and performance of the trees during is maturity stages. Just as mentioned by [1] that the canopy diameter, plant height and leaf drop were all different. The canopy diameter and Leaf drop are useful indicators to the growth of the plants for the design of irrigation and management purposes. Leaf drop indicates the stress severity. This can be seen during dry seasons, the leaves are shedding to reduce the water loss. Leaf dropping can lead to slow growth as indicated by the amount of the leaf drop and the reduction of the canopy diameter. The table below shows the difference in canopy diameter, plant height and leaf drop in the irrigated vs non – irrigated systems.

Table 2-1: Difference in trunk girth, canopy diameter, plant height and leaf drop in irrigated vs non – irrigated systems.

Treatment	Trunk girth increment (cm)	Canopy diameter increment (m)	Plant height increment (m)	Leaf drop (g) 1993
Water level				
W1 (0 L/day)	18.5	1.23a (100)	1.18a (100)	2 831a
W2 (75 L/day)	22.6	1.99b (162)	1.73ab (147)	662b
W3 (100 L/day)	22.8	2.21b (180)	2.04b (173)	612b
Clone				
D24	23.3	1.98	1.65	2 142a
D99	19.9	1.63	1.65	596b

Another important aspect that should be considered is the water requirements, not just all the time, but for the different phases in its maturity phase. According to Surmsuk, from the Horticultural Research Centre [8], The flowering process and fruiting management is crucial to the improvement of durian production. A timeline of the flowering process is described in a timeline, showing different important points throughout the flowering process in Figure 1 below.

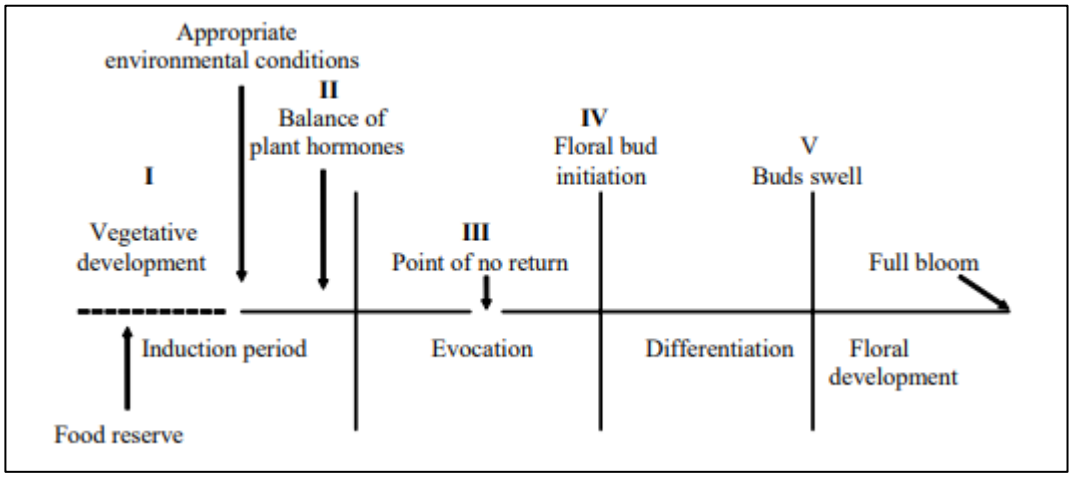

Figure 2-1 : Flowering Process of Durian [8]

In step 1, the vegetative development is the growth of the durian tree, the tree is grown and usually manipulated to undergo photosynthesis as much as it can. The vegetative growth lasts for approximately 4 to 5 years [1]. As mentioned in [8] that the flowering stage is likely to start when the durian tree stops receiving water or any moisture from 7 to 14 days or 1 week to 2 weeks. The flowering stage can be indicated by the presence of the bulb like structure that stems from the main trunk of the trees [1],[8] as shown below in Figure 2.

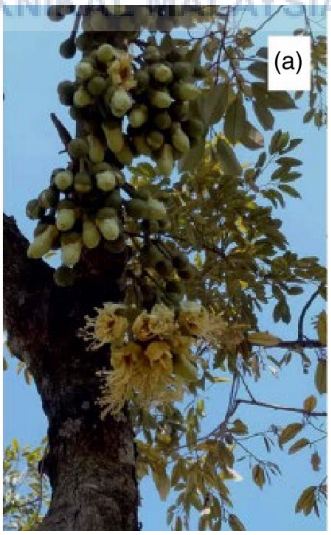

Figure 2-2 : Flowers of the durian on the main trunk.[1]

The flowers shown are many as shown in Figure 2 above, as mentioned in [1] that it is not common for it to grow on the main trunk and on the lateral branches. The flower cluster contains about 8 to 20 or more individual clusters. Despite the great number, only 1 or 2 fruits are set and harvested from each cluster. The flowers from the same cluster do not develop at the same rate, thus causing variation in fruit size to occur during the harvest. Figure 3 below shows the flowers after it has bloomed.

Figure 2-3 : Flowers bloomed.[1]

Previously mentioned, for the durian to start its flowering stage, it requires 1 to 2 weeks of dry conditions to occur before it starts to flower as mentioned by [8], however in [1] it mentions that it occurs in 3 to 4 weeks. Other factors that is related soil could account for this deviation. Also mentioned by [1] that continuous long periods of drought may prevent the durian trees from stimulating the flowering phase of the durian and does not produce more flowers. Similarly, watering or making humid conditions will lead to result in a reduction of the flowers produced. The conclusion achieved by both [1] and [8] is that a level of drought, with subsequent bud growth required a moderate level of irrigation that led to the highest number of flowers.

2.3 Root Activity

Root activity of the durian's roots plays a heavy influence on the growth of the durian trees. Few journals have written well about the root distribution and the activity that occurs. The root activity can also influence the design of the irrigation system intended to be used because to achieve the perfect conditions as described in subtopic 2.1, a reference point must be determined to achieve the best results. In [9], the author describes the durian tree with a drawing as shown in Figure 4.

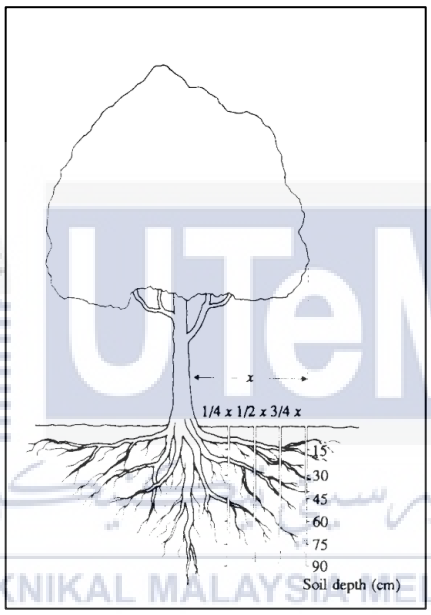

Figure 2-4 : Schematic diagram of a durian tree

The experiment done in 1988 by Mardi was executed by collecting the root samples of multiple durian populations at MARDI stations from Bertam, Jerangau, Serdang and Kuala Kangsar. Four trees were randomly selected from the orchard of budded D24 Durian clones. The selected trees happened to be around the 4 to 5 years old age and almost similar girth size and canopy diameter. The soil type and characteristics were tabulated in Table 2 below.