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Growth performance of durian based on crop water requirement (ETc) using irrigation system

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Abstract

Water use for agricultural production in water scarcity regions requires precise irrigation water for sustainable irrigation management. The correct amount of irrigation water should be applied to ensure the survival of plants. Currently, farmers apply irrigation without considering the actual amount of the crop water requirement (ETc), which may lead to over or under-irrigation. These problems may cause water logging, crop stress, reduced yield and inefficient farm management. Durian (*Durio zibethinus)* is an important economic crop of Southeast Asian countries, including Thailand, Malaysia, and Indonesia. Lately, durian plantation has been increasing in Malaysia with innovative and sustainable approaches through irrigation or fertigation. The growth of durian is highly affected by water and nutrients given to the plants. This paper highlights the effect of precise irrigation through durian water requirement. Hence, this study aims to compare the difference in growth performance between existing practices (irrigation without ETc) and irrigation based on ETc. The study was conducted in the durian plantation at Sri Lalang, Kluang, Johor. There were two treatments tested on the durian, which are treatment 1 (T1) existing practice (irrigation without ETc) and treatment 2 (T2), irrigation based on ETc. The experimental design for this experiment is a Randomized Complete Block Design (RCBD) with four (4) blocks, and four trees for each treatment per block. The data collection includes the height of the tree, canopy width, girth's diameter, node distance, leaf length and leaf weight. These data were analysed using ANOVA and LSD. Data was collected from April until November 2020. There was a significant difference in node distance from April until September. However, there were no significant differences for other growth parameters, suggesting precise crop water requirement can save water and minimize cost for the whole irrigation management.

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1. INTRODUCTION

Durian (*Durio zibethinus*) belongs to the genus Durio and the family of Bombacaceae. It is the most important economic native fruit of Southeastern Asia countries including Thailand, Malaysia, and Indonesia. Durian fruit is characterized by its large and hard-torn covered husk. It also has a unique taste with a strong aroma. Durian primarily finds export markets in Asia, with some non-Asian destinations, including Australia, the United Kingdom, and Canada (Safari *et al.*, 2018). Traditionally, Singapore and Hong Kong have been the main export destinations, and China has been added to the list of countries receiving durian exports. Between the periods of 2002–2011 and 2011–2019, durian exports surged by 172% in constant dollar terms, following the acquisition of market access to China. During this timeframe, the export value rose by 151%, ascending from USD 8.8 million in 2011 to USD 22.3 million in 2019 (Safari *et al.*, 2021). Moreover, rainfall is expected to be well spread during the year with a short period of dry weather. A sustained duration of a drought of up to three months is unfavourable to durians, which can create significant harm which limit the growth and production of fruit trees (Ketsa *et al.*, 2020). Water stress has influenced a diverse array of physiological processes, including stomatal behaviour, photosynthesis, transpiration, and the translocation and partitioning of assimilates (Masri, 1999). The Malay clone D10 is highly compatible, providing better fruit production with the current recommended D24-larger, more rounded fruits with fewer seven (7) hollow locules (Shaari *et al.*, 1985). Besides, Malayan registered clones D2, D10, D24, and D145 were all selected from farmers' fields, while others are hybrids (D188, D189, and D190) formed from crosses using D10 and D24 – with D188 soft and creamy, and D190 moist in flavour (Sani *et al.*, 2015).

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In agricultural industries, water is essential to crop growth. Irrigation is important in the agricultural industries to help farmers produce a good quality of crop and fruit yield. Thus, irrigation can optimize water usage and improve water condition in soil, increase the water content of plant fibre, dissolve nutrients and make them available to the plants. Moreover, irrigation is important in the artificial application of water to overcome deficiencies in rainfall for growing crops (Nikolaou *et al.,* 2020). However, insufficient and excessive amounts of irrigation water can cause problems such as water logging at the planting area, leading to poor crop quality and reduced yield. In irrigated agriculture, the right way to save water is to increase water use efficiency through better management.

The available data regarding the actual water requirements for durian cultivated in the field is uncertain, and there is a scarcity of published reports on durian watering practices in Malaysia (Jaafar, 1998). Abdul Jamil and Ghani (1991) suggested an application of 8–10 litres per plant every 4–7 days during the initial year of field establishment. Meanwhile, Zainal Abidin et al. (1992) recommended daily watering at a rate of 6–8 litres per plant to mitigate flower abortion. According to Nik Masdek (1993), Thai growers adopt irrigation to align with the evapotranspiration (ET) demand, which is around 5 mm per day throughout the fruiting period. In clayey soil, irrigation is implemented at 3-day intervals, whereas sandy soil necessitates daily water application. Annual rainfall exceeding 2000 mm is ideal for durian production, and mean yearly total rainfall should exceed 3000 mm. According to Subhadrabandhu and Ketsa (2001), in the dry season, irrigation is important during long periods of drought. Moreover, durian roots have been reported to lack root hairs and form a vesicular-arbuscular mycorrhizal association (Smith *et al.,* 1998). To increase the quality of agricultural production and to reduce runoff, these findings are used in developing ideal nutrient and irrigation application strategies (Ketsa *et al.,* 2020). A prolonged drought 9 cycle does not allow plants to produce more flowers and moist-humid conditions contribute to a decline in the number of flowers. These findings indicate a cyclic reaction with flower buds requiring a drought level, followed by bud growth enhancement requiring a moderate irrigation level (Chandraparnik *et al.,* 1992). However, intensive irrigation has a small effect on the percentage of dry matter during harvesting. In contrast, the micro-environment in the orchards has a larger impact on the percentage of dry matter (Jerapat and Siriphanich, 2006). Additionally, irrigation with mini sprinklers is favoured, but adding the same volume of water takes longer. This application raises the canopy's humidity and increases tree growth (Palapol *et al.,* 2015). There is a need for further studies on the correct amount and timing of irrigation water that should be applied to ensure the survival of durian plants. The study addresses the significance of water in agricultural industries, emphasizing the importance of irrigation for optimizing water usage and enhancing crop quality and yield. Therefore, the study's objective is to compare the difference in growth performance between existing practice (irrigation without ETc) and irrigation based on ETc.

2. MATERIALS AND METHODS

2.1. Study area and experimental design

The study was conducted in the durian plantation at Sri Lalang, Kluang, Johor. The total area of the plantation is 40 acres consisting of 83% Musang King, 8% Black Horn and 5% golden Pheonic. All trees were at the vegetative growth stage aged between 5 and 8 months. The study was designed in a Randomised Complete Block Design (RCBD) with four (4) blocks and four (4) trees for each treatment per block. Each block contains two (2) treatments and is labelled as treatment 1 (TI) for existing practice (irrigation without ETc) and treatment 2 (T2) for irrigation based on ETc. Each treatment contained four (4) samples in each block, totalling 32 (Figure 1).

The source of water is from the groundwater pump and it will flow to the main line and next to the 16 sub-main lines. From the sub-main, water will flow into the laterals where the durian trees are in the study area. As many as five (5) drips were attached to a looped pipe for each tree, as shown in Figure 2. The flow rate of each drip was 8L/h. For treatment 1, irrigation was given according to the field management practice without considering ETc. This existing practice used an automatic timer to control water in the pump house. Irrigation water was given twice daily with the total amount of irrigation water 66 L/day. In treatment 2, the amount of water given through irrigation was based on ETc. The amount of water is given based on a calculation of ETc as in equation 1.

$$\text{ETc} = \text{Kc x ETo} \tag{1}$$

Crop coefficient, Kc is the standard crop coefficient taken from Hiranpradit *et al.,* (1992), where Kc = 0.6 for durian vegetative growth stage. ETo will be calculated from the Penman-Monteith formula using CROPWAT 8.0 software, incorporating the average previous five (5) years of climate data for Kluang station obtained from the Malaysian Meteorological Department (MET). The climate data includes daily temperature, wind speed, sun radiation and humidity. For this treatment, irrigation was also given twice daily.

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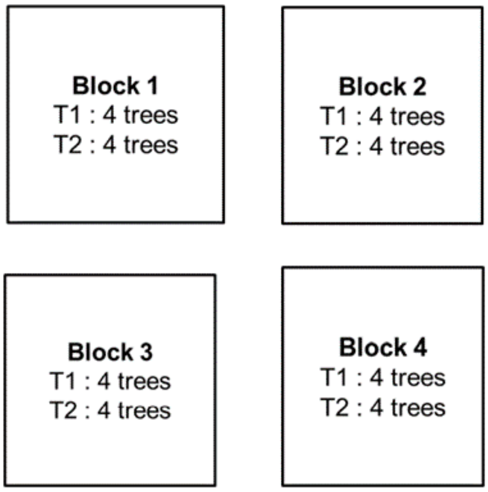

Figure 1: Arrangement of experimental design of durian trees

Figure 2: Five (5) drips per tree and each drip has a flow of 8L/h

2.2. Data collection

The growth of durian trees in each treatment was based on two irrigation methods: existing practice irrigation without ETc and irrigation with ETc. Data was collected once per month together with durian tree observation from April until November 2020. The growth performance of durian based on two treatments was measured by taking the leaf length, leaf width, girth, canopy, node distance, and height of durian trees.

2.3. Data analysis

The effect of each treatment on the growth parameter such as leaves length, leaves width, girth's diameter, node distance, canopy width, and height of trees was analysed using statistical Analysis Software (SAS). Analysis of Variance (ANOVA) was performed to find the significant effect of different growth parameters. Mean comparison using the Least Significant Differences (LSD) test at P< (0.05) was employed for mean comparison. Differences were considered significant when the P-value was <0.05.

3. RESULT AND DISCUSSION

3.1 Irrigation based on ETc

To calculate crop water requirement (ETc) based on climatic data of the cultivation area and standard crop coefficient (Kc) for durian during vegetative growth. Climate data includes the previous five (5) years of climate data for station Kluang from MET. The MET weather station in Kluang, Johor, distance 10 km from the study area. The crop coefficient (Kc) value was taken from the study of Hiranpradit et al. (1998) where the Kc value used in this study is at the vegetative growth stage (Kc = 0.6) as shown in Table 1. Table 2 shows the calculated ETo from the software.

The crop evapotranspiration (ETc) in mm/day can be calculated from the equation ETc = ETo x Kc. Table 3 shows the results of calculated ETc. It is observed that ETc for each month were different. The radius area to be irrigated is 1.5 m (as trees planted 3x3 m). The value of ETc is multiplied by the area to get the volume in meter cube (m^3) and later converted to litres per application. From the results it can be concluded that the amount of water applied in May until October were same (8L) while in February slightly higher (9L). The highest amount of water given through irrigation was observed in March (10L) and the least amount of water was given in November (7L). High temperature was observed in March which reflect the high ETc value and need of water, while in November and December are wet season with lower temperature.

Table 1: Developed Kc values for durian at different growth stages (Hiranpradit *et al.*, 1992)

Stage of development	Kc
Vegetative growth	0.60
Floral initiation	0.00
Floral development	0.75
Fruit Setting	0.50
Early fruit growth	0.60
Late fruit growth	0.85
Fruit maturity	0.75

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Table 2: Monthly ETo from CROPWAT 8.0 software

Month	Min Temp °C	Max Temp °C	Humidity %	Wind m/s	Sun hours	Rad MJ/m²/day	ETo mm/day
January	21.9	28.5	83	2.1	5.3	16.8	3.57
February	23.4	28.3	79	2.7	6.5	19.3	4.25
March	24.3	29.4	79	2	7	20.4	4.5
April	25.3	30.3	83	1.3	7.2	20.3	4.4
May	25.4	29.7	84	0.9	6.9	18.9	3.95
June	24.7	29.5	84	0.9	6.5	17.8	3.67
July	25.1	30	82	1.1	6	17.3	3.7
August	24.8	29	82	1.2	6.1	18.2	3.86
September	24.1	28.7	83	1.1	6.1	18.8	3.89
October	24.6	29.2	83	1	5.6	17.9	3.76
November	24.2	28.7	86	1.2	5.3	16.8	3.51
December	22.5	28.9	84	2	4.2	14.9	3.3

Table 3: Calculated ETc from weather station for February until November 2020

Month	ETo x Kc	ETc (mm/day)	ETc (l/day)	Per application (l)
February	4.25 x 0.6	2.55	18.10	9
March	4.5 x 0.6	2.70	19.17	10
April	4.4 x 0.6	2.64	18.74	9
May	3.95 x 0.6	2.37	16.83	8
June	3.67 x 0.6	2.20	15.63	8
July	3.70 x 0.6	2.22	15.76	8
August	3.86 x 0.6	2.32	16.44	8
September	3.89 x 0.6	2.33	16.57	8
October	3.76 x 0.6	2.26	16.01	8
November	3.51 x 0.6	2.11	14.65	7

3.2 Growth performance

The growth performance of durian resulting from two different applications of irrigation treatment are shown in Table 4. The result includes the height of the tree, girth's diameter, node distance, canopy width, leaf length, and leaf width. Data was collected from April until November 2020. During the study, the data collection was until November because of the movement control order (MCO) due to the pandemic in Malaysia. The measurement was not applicable due to the outbreak. Thus, the analysis of treatment was based solely on the plant growth parameters.

There was no significant difference between T1 and T2 for the height of a tree, girth's diameter, canopy width, leaf length and leaf width. Based on this result, it can be concluded that T1 and T2 had no effect on the parameters. This agrees with the study from Jaafar (1998) as no significant difference for durian in vegetative growth except for trunk girth which was only apparent after the third year. The study also showed that water treatments seemed to have no effect on fruiting at this age. Also, durian trees can grow well either with a controlled amount of water given by its water requirements or by the existing practice with a higher amount of water.

The result of node distance shown in Table 4 from April until September 2020 showed a significant difference between T1 and T2. However, there were no significant differences between T1 and T2 for October and November. The results showed that a longer node distance was observed in T1 compared to T2 from February until September. During the growth of the trees, a higher volume of water given in T1 affected the node distance. However, in October and November when the trees had grown bigger, the volume of water no longer affected the node distance. It can be concluded, with further observation, that as the durian tree grows bigger, the difference in the volume of water given has no effect on the node distance. The findings underscore the importance of precise water management tailored to the crop's water requirements. This

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aligns with sustainable water management practices, as mentioned by Ali *et al.* (2010), Mahmoud *et al.* (2019), and Gong *et al.* (2020), emphasizing the significance of applying the correct amount of water at the right time. Besides, this treatment can save costs by supplying adequate water as practiced in T2. Durian trees can grow well by providing them precisely according to the durian's crop water requirement. Climate-smart agriculture emphasizes precision in resource use. Adopting water management systems allows for precise control over irrigation, aligning water application with the actual needs of crops. This approach optimizes water use efficiency, reducing the overall water footprint of agricultural practices.

Table 4: Height of tree, girth's diameter, node distance, canopy width, leaf length, and leaf width according to the treatments; T1: Existing practice (irrigation without ETc) and T2: Irrigation based on ETc.

Month	Treatment	Height of tree (cm)	Girth's diameter (cm)	Canopy width (cm)	Node distance (cm)	Leaf length (cm)	Leaf width (cm)
April	T1	248.69[a]	7.24[a]	231.06[a]	3.08[a]	13.23[a]	3.87[a]
	T2	240.44[a]	7.41[a]	235.94[a]	2.51[b]	12.58[a]	3.81[a]
May	T1	259.13[a]	7.66[a]	245.25[a]	3.19[a]	13.51[a]	3.90[a]
	T2	247.94[a]	7.84[a]	247.81[a]	2.62[b]	12.97[a]	3.61[a]
June	T1	276.56[a]	8.21[a]	257.19[a]	3.25[a]	14.24[a]	4.16[a]
	T2	262.31[a]	8.37[a]	256.56[a]	2.71[b]	13.21[b]	3.77[a]
July	T1	287.25[a]	8.58[a]	280.38[a]	3.20[a]	14.83[a]	4.98[a]
	T2	276.44[a]	8.74[a]	284.25[a]	2.67[b]	15.07[a]	4.35[a]
August	T1	303.00[a]	8.87[a]	293.56[a]	3.30[a]	14.78[a]	4.36[a]
	T2	289.31[a]	9.04[a]	298.19[a]	2.76[b]	15.13[a]	4.58[a]
September	T1	319.19[a]	9.46[a]	303.75[a]	3.34[a]	14.29[a]	4.07[a]
	T2	297.50[a]	9.51[a]	307.19[a]	2.84[b]	14.14[a]	4.21[a]
October	T1	330.06[a]	9.80[a]	317.13[a]	3.34[a]	14.37[a]	4.15[a]
	T2	319.25[a]	9.84[a]	328.06[a]	2.91[a]	14.39[a]	4.13[a]
November	T1	342.44[a]	9.97[a]	322.38[a]	3.41[a]	14.89[a]	4.29[a]
	T2	326.69[a]	10.04[a]	331.94[a]	3.06[a]	14.89[a]	4.28[a]

4. CONCLUSION

This study attained the exact amount of water application rate for durian tree at the vegetative stage based on their crop water requirement. Based on the exact amount of water applied, no significant difference in growth performance between both treatments, suggesting that using the precise crop water requirement for irrigating durian trees can save water and minimize cost for the whole irrigation management. Instead of giving more water as practiced in T1, irrigation water can be applied precisely according to its crop water requirement to have the same growth performance.

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