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THE INFLUENCE OF WEATHER PATTERNS ON DURIAN YIELD IN MALAYSIA

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ABSTRACT The need to be able to be ahead of the forecast weather report can be a game changer. Thus, the utilization of a weather station in a farm could have an enormous impact. This study was conducted at Top Fruits Sdn. Bhd. durian farm located in Parit Sulong, Johor, Malaysia. This research spanned partially from January 2023 to December 2023 and involved the utilization of durian trees aged between 5 to 35 years old. The Davis Weather Station has been deployed in the farm to gather continuous weather data. Some notable findings were found which suggest a direct correlation between an increase in the humidity and a subsequent decrease in the durian harvest yield. The study identified 26.03 °C as the optimum daily average temperature for fruit development, which is the lowest average temperature recorded during the observation period. A high daily average evapotranspiration value, up to 2.68 mm as observed in this publication, favors the durian yield. Pearson's correlation analysis revealed no significant correlation between rainfall and yield, attributed to the use of sprinkler irrigation when rain was absent. It can be concluded that weather patterns significantly impact fruit development.

KEYWORDS : Durian, Weather, Yield

INTRODUCTION

Durian (Durio zibenthinus), commonly known as the "King of Fruits", is a tropical crop renowned for its distinctive aroma and taste. Cultivation of durian requires specific environmental conditions to ensure optimal growth and fruit development. Durian thrives in regions with an annual rainfall of 1500 mm or more, where water availability is essential for sustaining the durian tree's growth throughout the year (Shin, 2022). Additionally, the same research stated that durian trees prefer warm temperatures ranging from 24 to 32 °C, coupled with a relative humidity of 75% to 80% humidity. These climatic conditions create an ideal climate for durian trees to flourish and produce high-quality durian fruits. Moreover, it is crucial to highlight the significance of maintaining ambient temperatures above 22 °C to mitigate the risk of unfruitfulness, particularly since durian trees exhibit sensitivity to colder temperatures. This critical threshold ensures that the physiological processes important for flower and fruit development are not interrupted, thereby safeguarding the potential yield of durian plantations.

The shallow root system of the durian ranging from 20 cm to 40 cm in depth, underscored the necessity of supplemental irrigation across all the durian development phases. Durian grows well on slopes and foothills situated at altitudes between 600 to 900 m above sea level. Moreover, durian exhibits optimal growth in well-drained soil. Adequate water supply is very crucial, as even slight water stress could increase the durian mortality rate by up to 50% (Ismail, Aziz and Hashi, 1994). According to the official flooding website of Malaysia, rainfall intensity is categorized based on the accumulated rainfall amount in one hour in mm, with thresholds set by the Department of Irrigation and Drainage Malaysia at 1 – 10 mm for light rainfall, 11 – 30 mm for moderate rainfall, 31 – 60 mm for heavy rainfall, and more than 60 mm for very heavy rainfall.

The need to be able to be ahead of the forecast weather report is of utmost importance as the risk of plant mortality is ever present (Shin, 2022), making it cumbersome for some farmers who simply rely solely on limited and costly manpower. Manual cultivation activities such as inspection and irrigation that are carried out almost daily are the turning point to a successful yield, both in terms of quantity and quality, including taste (Shin, 2022).

Weather station is an important decision-making tool (Bayer, Tersel and Chappell, n.a). It is a set of instruments and sensors for collecting valuable farm weather and soil information. Weather station used locally in a farm records the microclimate that is ever present in the farm and since weather conditions alter within a small area, installing such technology benefits various farm programs.

Durian, valued for its high market demand, exhibits a prolonged fruit production cycle extending over several months. However, fruit production is always present throughout the year depending on the climatic conditions of the different locations and the farm practices of durian plantations that involve an intensive fruiting regime (Cong and Brady, 2012). Given the susceptibility of durian crop production to fluctuations in weather patterns, monitoring these changes is very crucial. Such monitoring enables a deeper understanding of the effects on durian yield and facilitates early forecasting of yield potential at the early of the season.

Utilizing weather data to forecast the yield is much more cost-effective than conducting field surveys and with longer lead times (Lobell, Cahill, and Field, 2006). According to Pathak, Dara, and Biscaro, (2016), a huge change in crop yield can be explained by variability in the weather. Records of daily yield and weather data are required to develop yield prediction tools for durians, with some climatic variabilities, especially with the frequent occurrence of The El Nino-Southern Oscillation (ENSO) (Pathak, Dara and Biscaro, 2016). Apart from affecting durian yield, the weather conditions could also play a huge role in durian marketability as yield influences the pricing of durian in the subsequent year following harvest. Forecasting the weather ahead of time lasting anytime from 3 to 6 months before harvest enables farmers to make decisions that would favour the yield (Jones et al., 2000). Therefore, the objective of the current study was to investigate and analyze the relationship between various weather patterns and durian yield in 2023, and to provide valuable insights into the effects of weather conditions on durian cultivation, aiming to optimize yield and overall production.

MATERIAL AND METHOD

This study was conducted at Top Fruits Sdn. Bhd. durian farm located in Parit Sulong, Batu Pahat, Johor, Malaysia (2°062158'N, 102°886042') (Figure 2.1). This research spanned partially from January 2023 to December 2023 and involved the utilization of durian trees aged between 5 to 35 years old.

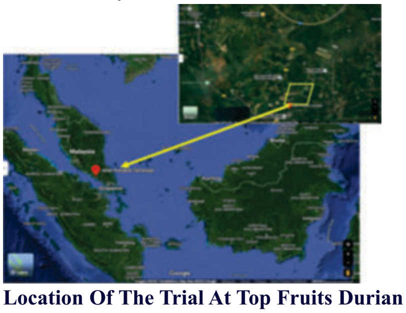

Figure 2.1: Location Of The Trial At Top Fruits Durian Farm In

Parit Sulong, Johor, Malaysia.
Source: Google Maps (2024)

Since May to June represents the peak of the on-season yield, this paper is focused on the weather and yield analysis during this period, along with an examination of the top 4 off-season weather and yield analyses. Daily durian yield data collected partially from January to December were aggregated into weekly and seasonal values for the year 2023. Additionally, this study also examines the historical yield data to discern any noteworthy trends, whether upward or downward, influenced by the weather conditions.

Season 1 parameters were collected from April to June, with harvest data gathered in May and June, aligning with the peak season. Season 2 parameters were obtained from January to March, with harvest data collected in March. Season 3 parameters were recorded from February to April with harvest data acquired in April. Season 4 parameters were gathered from June to August, with harvest data obtained in August. Lastly, season 5 parameters were observed from August to October, with harvest data recorded in October.

A weather monitoring system, Davis Weather Station provided by Netafim Ltd., has been deployed in the farm to gather continuous weather data (Figure 2.2). The collected data include temperature, relative humidity, rainfall, evapotranspiration (ET), wind speed, and solar radiation. Meanwhile, harvesting and rejection rate data were derived from the total durian yield in the farm.

Figure 2.2: Davis Weather Station In The Durian Farm

The results were analyzed using the Analysis of Variance (ANOVA) of SAS version 9.3 (SAS Institute, Cary, NC), and the means were compared by Tukey Honestly Significant Differences (Tukey's HSD) test at a significant level of p = 0.05. Pearson's correlation (r) analysis at p = 0.05 was conducted to determine the relationship between all the measured variable in the present study.

RESULTS

Humidity

Following an increase in the daily humidity, durian harvest decreased when big season was not considered (Figure 3.1). Hence the optimum humidity for durian fruit development is low at 86.97%. There is no significant difference among the seasons between the humidity and yield at p = > 0.05. The highest and lowest rejection rates were observed when the two highest humidity readings were registered at 88.2% to 88.3% respectively.

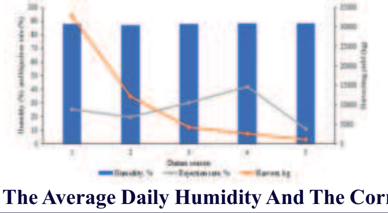

Figure 3.1: The Average Daily Humidity And The Corresponding Yield With Rejection Rate According To Season In 2023

Temperature

There is a significant difference among the seasons between the daily temperature and yield at p = < 0.05. During the fruit development phase, there is a trend of decreasing yield with increasing temperature till 26.84 °C (Figure 3.2). After this point, yield increases with increasing temperature. The optimum average temperature for fruit development is concluded at 26.03 °C which is the lowest average temperature, when big season is not considered, with the highest yield. Based on Tukey's Studentized Range (HSD) Test for temperature, season 2 has the lowest temperature with a relatively high yield.

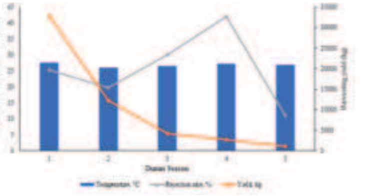

Figure 3.2: The Average Daily Temperature And The Corresponding Yield With Rejection Rate According To Season In 2023

Evapotranspiration

There is a significant difference between daily evapotranspiration and yield among the seasons at p = < 0.05. It is observed that with increasing evapotranspiration, yield increases up to 2.62 mm, before fluctuating (Figure 3.3). However, without considering the big season, with increasing evapotranspiration value, durian harvest increased. Hence, a high evapotranspiration value, up to 2.68 mm as observed in this publication, favors the yield. Based on Tukey's Studentized Range (HSD) Test for evapotranspiration, Seasons 4 and 5 exhibited the lowest evapotranspiration values with the corresponding lowest harvest as compared to the other seasons.

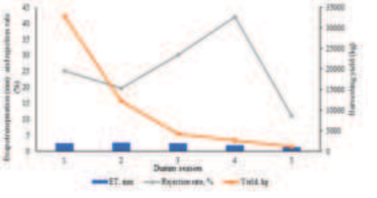

Figure 3.3: The Average Daily Evapotranspiration And The Corresponding Yield With Rejection Rate According To Season In 2023

Rainfall

There is a significant difference among the seasons between the daily rainfall and yield at p = < 0.05. With increasing rainfall, the harvest increased up to 7.33 mm rainfall without considering the big season, before decreasing (Figure 3.4). Thus, an optimal rainfall at 7.33 mm on average in a season as observed in the data gives a high harvest.

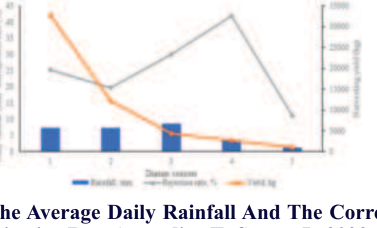

Figure 3.4: The Average Daily Rainfall And The Corresponding Yield With Rejection Rate According To Season In 2023

Wind Speed

It is observed without considering the big season, with increasing daily wind speed, durian harvest increased up to 0.88 km/h (Figure 3.5). With further increasing speed, harvest decreased followed by an increasing harvest from 0.89 km/h to 1.08 km/h. The highest rejection rate was seen when the second highest wind speed was seen at 0.89. Fruit losses were most likely caused by premature fall.

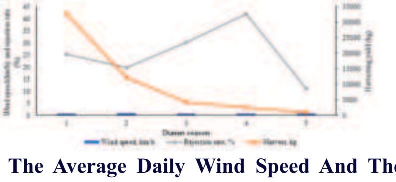

Figure 3.5: The Average Daily Wind Speed And The Corres-

ponding Yield With Rejection Rate According To Season In 2023

Solar Radiation

It is observed that with increasing daily solar radiation, the yield decreased to 131.10W/m² when big season is not considered before a fluctuation in the yield is observed (Figure 3.6). The highest yield was recorded when solar radiation was 134.90W/m² at the point when the yield started to decrease for the second time.

The relatively high rejection rate was observed with the highest solar radiation at 138W/m². The rejection is most probably caused by a high incidence of crack as radiation is known to cause the fruits to crack.

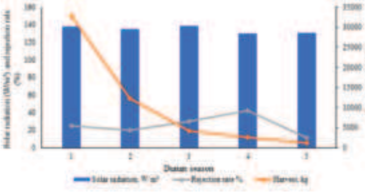

Figure 3.6: The Average Daily Solar Radiation And The Corresponding Yield With Rejection Rate According To Season In 2023

Pearson's Correlation

Pearson's correlation (Table 3.1) was performed to determine the relationships between all the independent variables. There was a significant, negative, and moderate correlation (r = - 0.41383) between humidity and evapotranspiration and this indicated that an increase in humidity resulted in a reduction in evapotranspiration. Besides that, there was also a significant, negative, and moderate correlation (r = - 0.47780) between humidity and solar radiation. The weather pattern shown is due to the solar radiation increasing the evaporation and transpiration rate while decreasing the content of water particles in the air. Meanwhile, the relationship between temperature and harvesting yield with rejection shows a significant difference at p = <0.05, with a weak association.

Table 3.1: Pearson Correlation Coefficients (r) Between Relative Humidity, Temperature, Evapotranspiration (ET), Rainfall, Wind Speed, Solar Radiation, Harvesting Yield And Rejection Rate Of Durian Trees At 5 Different Seasons In 2023.

	Temp	ET	Rainfall	Wind	Solar	Yield	Rejection
Humidity	-0.105ns	-0.414**	0.379*	-0.276*	-0.478**	-0.021ns	-0.122ns
Temp		0.066ns	-0.383*	-0.313*	0.327*	0.275*	0.360*
ET			0.225*	0.023ns	0.512**	0.207ns	-0.045ns
Rainfall				0.084ns	-0.265*	0.060ns	-0.152ns
Wind					-0.352*	0.025ns	-0.188ns
Solar						0.233*	0.125ns
Yield							0.024ns

ns = non-significant, *, ** = significant at p = 0.05 or 0.01, respectively

DISCUSSION

From this research, the findings suggest that the optimum daily average humidity level for durian fruit development is relatively low at 86.97%. Notably, a direct correlation was observed between increased humidity levels and a subsequent decrease in durian harvest yield. Furthermore, the study identified the optimum daily average temperature for fruit development to be 26.03 °C, the lowest temperature recorded during the observation period. However, as temperatures increased beyond this threshold, up to 26.84 °C, there was a discernible trend of diminishing yield during the fruit development phase.

The results also highlighted the significance of evapotranspiration (ET_0) in influencing durian harvest outcomes. Evapotranspiration, which encompasses the combined effects of humidity and temperature, emerged as a critical factor contributing to durian yield. A high daily average ET_0 value, up to 2.68 mm as observed in this publication, favors the durian yield, despite conventional wisdom suggesting that drought conditions and higher vapor pressure deficit may negatively impact fruit retention (Normand, Lauri and Legave, 2015).

This is probably due to other factors such as the fruit weight that contributed to a higher yield. The reference ET_0 in a study across the seasons and mango development period in May in a subtropical climatic condition in the Lucknow region was recorded as 1.82 to 31.21 mm/day (Adak, Kumar and Singh, 2015). The temperature in May during mango fruit development meanwhile was averaged at 23.8 to 39.9 °C (Adak, Kumar and Singh, 2015). Kennedy et al. (2009) published a study noting a high relative humidity of 90% aiding the conversion of residual food reserves into flower primordia in mango trees.

Increasing daily average rainfall, up to an average of 7.33 mm per season was found to positively impact the durian harvest yield. However, Pearson's correlation analysis revealed no significant correlation between rainfall and yield, attributed to the use of sprinkler irrigation when rain was absent. This discrepancy underscored the importance of irrigation practices in mitigating water stress during fruit development, thereby minimizing fruit drop. Water deficit reduced vegetative growth, water status, stomatal response and the rate of photosynthesis in the plants (Ismail, Aziz and Hashi, 1994). Plants grown at 10% of field capacity had significantly lower leaf area, leaf and root dry weight, root length and root volume (Ismail, Aziz and Hashi, 1994). At harvest, the leaf area and dry weight of plants grown at 10% field capacity were 50% less than those of the control at 80% field capacity (Ismail, Aziz and Hashi, 1994). Furthermore, rainfall affects the soil moisture which then affects the surface temperature through sensible heat and latent heat besides cloudiness, heat capacity, relative humidity, albedo effect and roughness (Huang and Van Den Dool, 1993). Additionally, rainfall typically affects the leaf area and photosynthetic efficiency while temperature variations influence the length of the growing season (Cong and Brady, 2012). The timeline in Figure 4.1 shows the length of the growing season which lasts for 90 days from the onset of flower bloom.

Figure 4.1: Big Season Timeline From Flowering To Harvest

The highest rejection rate was seen when the second highest daily average wind speed was seen at 0.89km/h. Fruit losses were most likely caused by premature fall. Premature fruit fall, likely induced by wind, accounted for the majority of fruit losses. This underscores the significant impact of wind on durian yield, especially when comparing sheltered and open durian farms during episodes of relatively high wind speeds. It is crucial to mitigate wind damage, as storms and typhoons can have disastrous consequences for durian crops. The wind speed ranged from 1.0 to 4.9 km/h in the Lucknow region, deemed suitable for mango production (Adak, Kumar and Singh, 2015). The highest yield was recorded when daily average solar radiation was 134.9026W/m², which is the medium value, at the point when the yield starts to decrease for the second time. Unusually high direct solar radiation could cause leaf bruising and reduce the growth rate.

The effect of solar radiation on growth is more apparent than the effect of temperature and soil water that is altered by solar radiation (Waister, 1972). Durian has a non-existent row orientation field aspect as it is grown in the tropical region with sunlight all year long and plant growth is present throughout the year, hence any orientation will not maximize the plant sunlight exposure. Soil water content and temperature stimulate fruit bearing and both are affected by the infrared reflective-IRR (Li et al., 2010).

CONCLUSIONS

The optimal conditions for durian fruit development were found to be a low humidity of 86.97% and a temperature of 26.03°C. Additionally, high evapotranspiration values, reaching up to 2.68 mm, were observed to positively influence yield. An average rainfall of 7.33 mm per season was deemed optimal for fruit development. Conversely, the highest rejection rate occurred at a relatively high wind speed of 0.89 km/h, while the highest harvest was observed at a solar radiation level of 134.90 W/m². Notably, the highest solar radiation at 138W/m² registered the relatively high rejection rate.

In conclusion, weather patterns significantly impact fruit development. This study did not consider factors such as mother tree relationship, physiology, crop load, and farm management practices holistically. Nonetheless, the weather data reported here holds potential for application in greenhouse-grown durian trees of dwarf varieties. Since the main durian harvesting season spreads over 2 months, studying the relationship between meteorological data and durian yield can provide important indications to predict durian yield that farmers can use to their advantage for marketability and other utilizations. Moreover, the climatic factors recorded can serve as invaluable time series data to quantify the general trend of climate change and its impact on durian cultivars' behavior. Orchard management techniques tailored to these findings, such as improving irrigation efficiency, managing tree canopy and flowering, and designing orchards to create a favorable microclimate, should be developed to optimize durian cultivation practices.

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