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Climate Influences on Latex Yield in South Sumatra, Indonesia

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ABSTRACT
This study addresses the impact of climate variability on latex yield. Field research was carried out in the Indonesian Rubber Research Institute Experimental Field, located in South Sumatra, Indonesia for 2020 to 2022. The study used mature IRR 118 clones of rubber (*Hevea brasiliensis*) planted in clay loam soil. Latex yields for dry and rainy seasons were compared to obtain the effects of climatic factors. A purposive sampling of latex clone IRR 118 was applied in the field. The results showed that declined rainfall and soil moisture content contributed to the low latex yield during dry season. A declined water availability acts as a limiting factor resulting in decreased latex yield. Latex yield consistently decreased when soil moisture content fell below 21.5%. Based on statistical analysis, the correlation between latex yield and climate factor was 0.36, 0.42, and 0.52 for rainfall, soil moisture content, and evapotranspiration, respectively. Our findings highlight the crucial influence of climatic factors, emphasizing the significance of optimal water availability for latex production.

KEYWORDS
dry season, evapotranspiration, IRR118 clone, rubber, soil moisture content

INTRODUCTION

The rubber plant (*Hevea brasiliensis*) is widely cultivated in the South Sumatra as it's climatic factors support the living conditions for rubber. In general, rubber has a good adaptability to various soil and climate condition that support better growth. Latex yield, as a product of rubber, tend to decrease following low rainfall and soil moisture content in dry season. Limited water became a constraint on the optimum rubber yield (Cahyo et al., 2022; Sahuri, 2017). Latex is a cytoplasm composed of 60% water. Deficit in soil water will immediately decrease latex regeneration capability. In dry season, rubber production might be only 50% of production in wet season (Gohet et al., 2015).

The land suitability for rubber includes an annual rainfall of 2,000 mm or more evenly distributed rainfall throughout the year (Ridgman, 1989). Climate conditions in South Sumatra is suitable for plantation, but during strong monsoon or El-Nino, dry season may last for 3-4 months (Muharomah and Setiawan, 2022; Sahuri, 2017), which reduces soil water availability (Taufik, 2010a). This condition may influence rubber production due to water stress during dry season (Larcher, 2001; Isarangkool Na Ayutthaya et al., 2011). Rainfall variability is one of the factors that causing non-optimal latex yield (Jacob et al., 2018; Kunjet et al., 2013; Rao and Vijayakumar, 1992). In South India, drought could reduce rubber production at least 36% (Rao et al., 1998).

Due to the decrease in latex yield during the dry season, it is necessary to study further the influence of climate and soil water availability on latex yield in South Sumatra. Therefore, this research specifically aims to determine the correlation between climatic factors and soil water on latex yield of IRR 118 rubber clone in South Sumatra, Indonesia, providing valuable insights for sustainable rubber cultivation practices in the region.

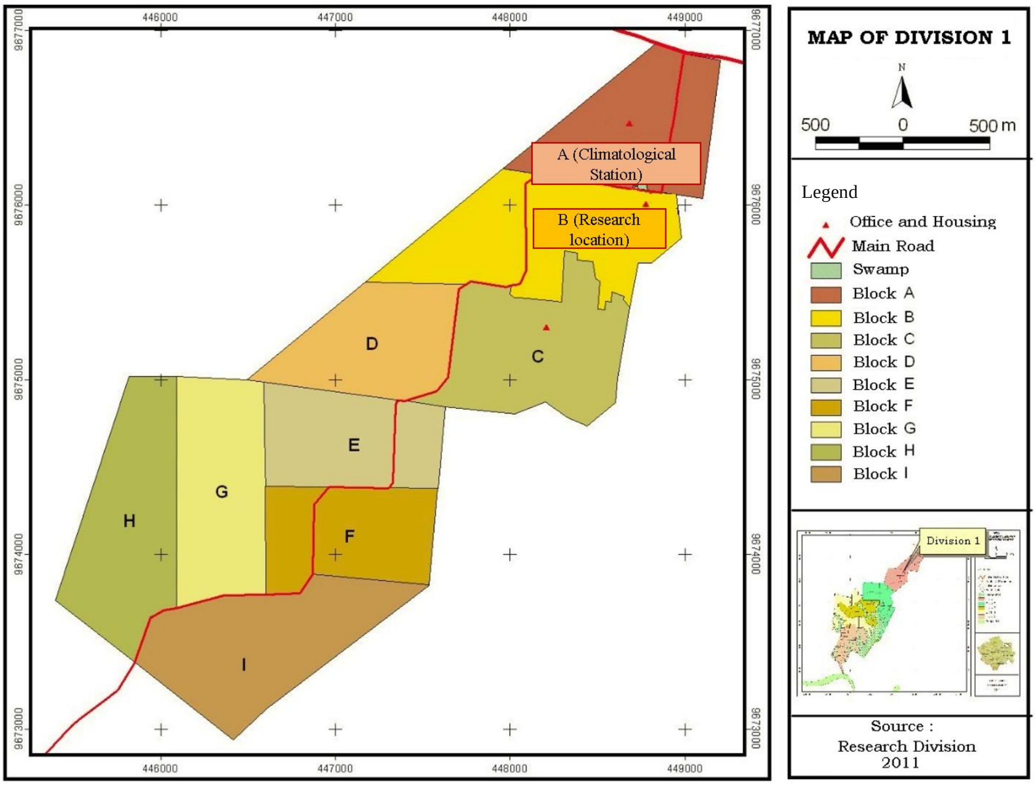

Figure 1. A map of study site at Indonesian Rubber Research Institute Experimental Field, Sembawa, South Sumatra.

RESEARCH METHODS

Study Area

This study was conducted in the Indonesian Rubber Research Institute Experimental Field in South Sumatra, Indonesia for 2020 to 2022 (Figure 1). We used mature period clone IRR 118, which was planted in 2013 on a clay loam soil texture. Rubber trees were planted in a 6 x 3 m spacing. The research area was five ha, with a total of 550 rubber trees per ha. The sampling procedure of latex clone IRR 118 was a purposive sampling.

Latex yields in dry and rainy seasons for 2020 - 2022 were compared to determine the effect of rainfall, soil moisture content, and evapotranspiration on it. The parameters that were monitored in the field included rainfall (mm) and soil moisture content (mm), and evapotranspiration (mm) were collected every month in latex yield gram tree^{-1} tapping^{-1} (g/t/t) for three years (2020-2022). Daily climate data for 2020–2022 was obtained from Automatic Weather Station (IoT RK900-0) at the institute in Sembawa, South Sumatra.

Data Processing

Water balance analysis was obtained through field water balance (FWB) calculations. The FWB model used in this research was based on Thornthwaite and Matter (1957) and precipitation (P) as the input. Water balance was calculated in Equation 1-5 (Nugroho et al., 2019). Description of the acronyms used in the equation were in Table 1.

$$\mathrm{In} = \mathrm{Out} \quad (1)$$

$$\mathrm{P} = \mathrm{ETP} + \mathrm{S} \quad (2)$$

$$\mathrm{ETA} = \mathrm{P} + \mathrm{dAWC} \quad (3)$$

$$\mathrm{D} = \mathrm{ETP} - \mathrm{ETA} \quad (4)$$

$$\mathrm{S} = \mathrm{P} - \mathrm{ETP} - \mathrm{dAWC} \quad (5)$$

Potential evapotranspiration (ETP) values were calculated using the Penman-Monteith method (Equation 6) (Allen et al., 1998; Alexandris et al., 2008).

$$\mathrm{ETP} = \frac{0.408\Delta(R_n - G) + \gamma\frac{900}{T+273}u_2(e_s - e_a)}{\Delta + \gamma\,(1 + 0.34u_2)} \quad (6)$$

Apart from calculating the evapotranspiration value, available water capacity (AWC) is also calculated based on the land water balance as shown in Equation 7 – 8.

$$\mathrm{k} = \mathrm{Po} + \frac{\mathrm{P1}}{\mathrm{FC}} \quad (7)$$

$$\mathrm{AWC} = \mathrm{FC} \times \mathrm{k}^{a} \quad (8)$$

The maximum soil moisture content stored in soil was limited by the soil field capacity, which was determined based on soil texture. According to FAO (2005), soil texture of clay loam has a field capacity value of 215 mm. The correlation between climate variables and latex yield was analyzed with the SAS v.9 statistical program.

Table 1. Acronym description.

Acronym	Explanation	Unit
ETA	Actual evapotranspiration	mm/day
S	Water surplus	mm
D	Water deficit	mm
Rn	Net radiation on the plant surface	MJ/m^2
G	Soil heat flux density	MJ/m^2day^1
T	Air temperature	°C
Ea	Actual vapor pressure	kPa
Es	Saturated vapor pressure	kPa
u_2	Wind speed at a height of 2 meters	m/s
γ	Psychometric constant	kPa/°C
Δ	Slope of the vapor pressure curve	kPa/°C
a	Absolute value of accumulated potential water loss	-
k	Constant value	-
FC	Soil moisture content at field capacity	mm

RESULTS AND DISCUSSION

Rainfall is closely related to the latex yield of rubber plants. In rainy season, it is necessary to use a rain guard to shield latex yields from rainwater (Thomas and Wijaya, 2013). Figure 2 shows the effect of rainfall, evapotranspiration, soil moisture content and water deficit on the latex yield of IRR 118 rubber clone for 2020–2022. There was an increased latex yield on the wet month, but a decreased latex yield was observed in dry month. In 2022, rainfall was evenly distributed throughout the year, which provided adequate water supply for photosynthesis process. This consequently led to heightened rubber growth, elevated latex yields, and improved quality of the latex yield. Ardika and Cahyo (2020), identified a positive correlation between rainfall and the production of the PB 260 rubber clone,

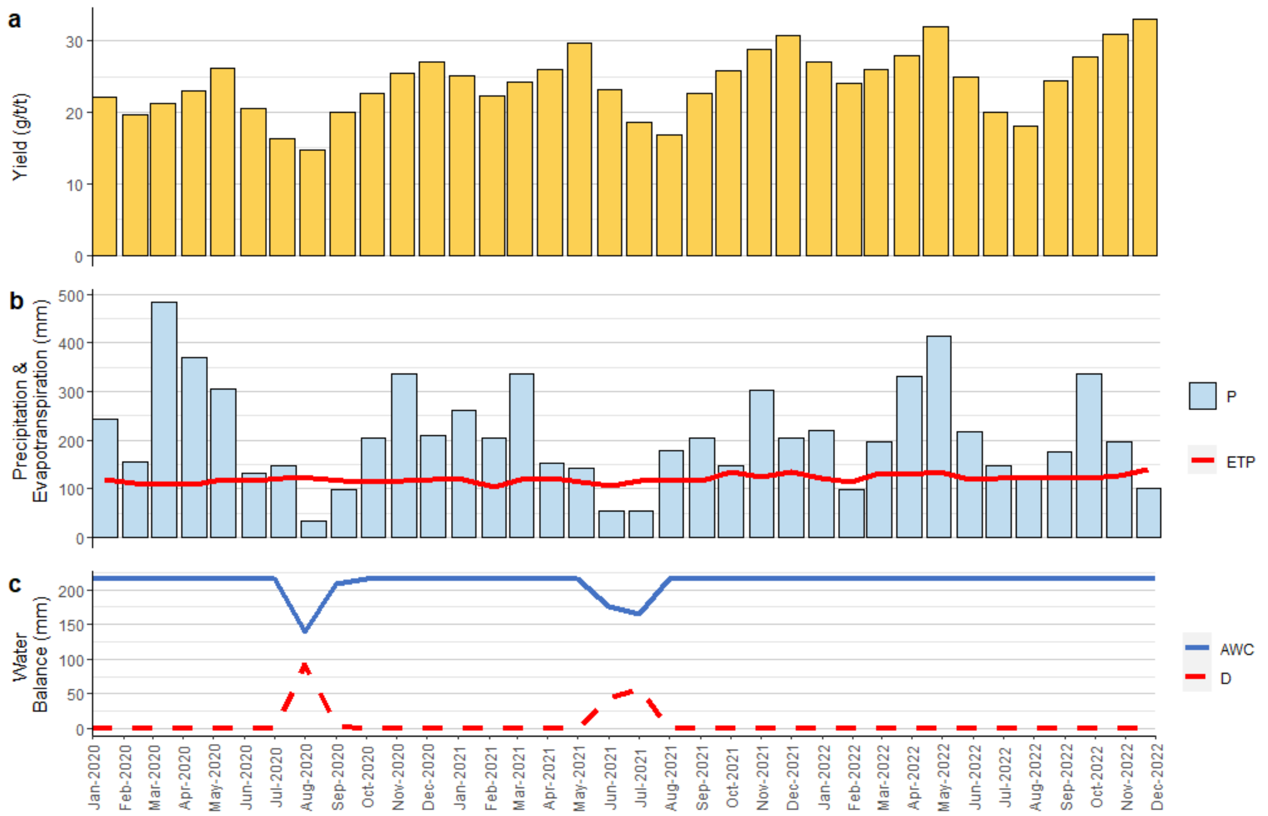

Figure 2. Temporal Patterns of (a) Latex Yield (Clone IRR 118) in Relation to (b) precipitation (P) and evapotranspiration (ETP), and (c) available water capacity (AWC) and water deficit (D) in Sembawa, South Sumatra, Indonesia (2020-2022).

Table 2. Correlation between rainfall in the n month and latex yield of the IRR 118 clone in the n to n+6 months.

Correlation parameters	P-value (*probability*)	r (*correlation*)
Rainfall and latex yield in the same month	0.03	0.36^{*}
Rainfall in month n and latex yield in month n+1	0.02	0.38^{*}
Rainfall in month n and latex yield in month n+2	0.02	0.38^{*}
Rainfall in month n and latex yield in month n+3	0.01	0.46^{**}
Rainfall in month n and latex yield in month n+4	0.01	0.46^{**}
Rainfall in month n and latex yield in month n+5	0.07	0.33^{*}
Rainfall in month n and latex yield in month n+6	0.89	0.03^{tn}

Note: ** significant correlation at the 0.01 level; * significant at the 0.05 level; and ^{tn} the correlation is not significant

spanning from one to 3-month lead time. Study showed that latex yield increased during the rainy season under irrigation as reported from a field experimental plot in Thailand (Mak et al., 2008). In this study, latex yield in wet season was around 40-50% higher than in dry season.

Decreased rainfall led to water deficit, which resulted in decreased latex production. In 2020 and 2021, prolonged water deficit had caused a declined latex as shown in Figure 2. The decline in rubber production in dry season is 50% of wet season (Gohet et al., 2015). In the wet zone area of Sri Lanka, a reduction in rainfall produced rubber yield, which was 35% lower compared to normal climate condition (Alahacoon and Giriraj, 2022). In dry months, rubber plants experience high temperatures and insufficient rainfall causing moisture stress, which is the limiting factor for maximum latex yield (Kunjet et al., 2013; Ardika and Cahyo 2020). Moisture depletion was associated to reduced growth and latex yield (Raj et al., 2005).

From Figure 2c, the maximum available soil water is 215 mm or equal to 21.5%. Any surplus rainwater will be converted into runoff or percolation. Dynamics of soil moisture content related to rainfall and evapotranspiration (Taufik, 2010b). Soil water depletion occurs in the absence of rainfall. Prolonged depletion caused moisture stress as shown during Jul-Sep 2020 and Jun-Jul 2021. By the depletion, latex yield was substantially affected (Figure 2). Statistical analysis showed that rainfall was positively correlated with the yield of latex clone IRR 118 from the same month to the following three months, which depend on the water content stored in the soil. Table 2 highlights the correlation between rainfall and latex production. The highest correlation was achieved by rainfall in month n and latex production in months n+3 and n+4. This showed that rainfall was still sufficient to maintain soil water closed to field capacity until 3-month ahead. According to Cahyo et al., (2017), prior to rainy season, defoliation still occurred, which caused rubber trees could not consume water normally due to limited transpiration. Therefore, excess rainfall was stored in the soil and utilized later by rubber plants until reaching the permanent wilting point in the sub-sequent dry season.

Table 3 indicates that rainfall, soil moisture content, and evapotranspiration were very significantly correlated with the latex yield of IRR 118 clone rubber plants. Water balance parameters had a direct effect on the amount of water consumed by rubber plants. Based on statistical analysis, rainfall, soil moisture content, and evapotranspiration had an influence on latex yields by 36%, 42%, and 52%, respectively. This indicated that rainfall and soil moisture content could be an indicator for latex production.

In 2020 - 2022, water deficit occurred in 2020 and 2021 (Figure 2c). The highest water deficit occurred in August 2020 (93 mm) causing lowest latex production of 15 g/t/t. For 2021, water deficit happened in June and July (44 and 57 mm, respectively), which produced 26% lower from 2020 latex production. Prolonged water deficit reduces photosynthesis and all physiological processes become abnormal. This also resulted in stunted plants, low latex yields, and reduced quality (Kunjet et al., 2013; Mesike and Esekhade, 2014). Other study mentioned that water deficit results in the delay of rubber stem maturity by 0.65 cm/month and 50% decline in latex yield (Cahyo et al., 2022).

Table 3. Correlation between rainfall, evapotranspiration, soil moisture content, and IRR 118 clone latex yield in Sembawa, South Sumatra, Indonesia, from 2020 to 2022.

Regression equation	R^2	P-value (*probability*)	r (*correlation*)
Y = 0.015*CH + 20.944	0.13	0.033	0.36^{*}
Y = 9.933*ETC – 14.922	0.27	0.001	0.52^{**}
Y = 0.118*KAT – 0.583	0.17	0.012	0.42^{*}
Y = 0.010*CH + 0.260*ETC + 0.070*KAT – 23.507	0.42	0.0005	0.65^{**}

Note: ** significant correlation at the 0.01 level and * significant at the 0.05 level

CONCLUSIONS

The results showed that rainfall, soil moisture content, and evapotranspiration had an influence on latex yields by 36%, 42%, and 52%, respectively. A decline in latex yield related to the decreased rainfall and soil moisture content during the dry season. To minimize water depletion in dry season, surplus water in rainy season should be collected such as through the establishment of a pond (reservoir) and a biopore for water conservation. A solution to cope with excess rainfall in the wet season that can disturb tapping activity is the adoption of a rain guard. Rain-guard technology is able to cope with latex yield loss when rainfall is high.

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