Monitoring and climatic data use for rubber plantation management

T Wijaya\textsuperscript{1,2} 
\textsuperscript{1}Indonesian Rubber Research Institute, Jl. Salak No. 1, Bogor 16151
E-mail: wijaya_thomas@yahoo.com

Abstract. Climate is a resource for growth and crop yield of rubber and many other crops. Climatic elements are needed to be recorded and interpreted and used for agronomic management. In this paper, the use of climatic data for the agronomic management of rubber plantation is presented. El Niño and La Nina has been known and could be anticipated 3 months earlier so that dealing with drought and wet condition can be anticipated in the rubber plantation. Climatic elements would be easier to be recorded by the automatic weather station. The observed climatic data could be used for calculation of water requirement for irrigation in the nursery, disease prevention, tapping management, planting time and potency of growth by using crop models.

Keywords: climate, rubber plantation management,

1. Introduction

The rubber tree is a tropical crop that can grow well in regions having rainfall between 1,500 to 3,000 mm per year with even distribution. Because most of the rubber plantation is located in a high rainfall area, the water is frequently not considered as a limiting factor, and people put less attention on water availability.

Climate, especially rainfall varies with time and this variation now days tends to be greater [1]. Great rainfall variation is a problem for dryland agriculture because water requirement solely relies on rainfall [2]. The amount and variation of rainfall distribution from year to year is the main factor for yield fluctuation. It has been known that the growth of crops is closely related to the water requirement for transpiration [3].

Research and experience for the last few decades showed that El Nino-Southern Oscillation is one important factor causing the variability of rainfall in many countries [4]. El Nino-Southern Oscillation (ENSO) is a phenomenon where sea temperature in Central and East Pacific increases which resulted in low rainfall in Indonesia and many countries. On the other hand, La Nina is causing a rainfall increase in Indonesia [5].

In Indonesia, long dry season in the 1990s occurred in 1991, 1994 and the extreme occurred in 1997 where dry season became longer and marked compared with other years, and the last El Nino year occurred in 2014-2016

\textsuperscript{2} To whom any correspondence should be addressed (wijaya_thomas@yahoo.com)
The impact of the long dry season is yield reduction and poor growth and also the risk of fire increase [6]. In this paper, it describes the utilization of climatic data for rubber plantation management.

2. Material and Method

The paper is designed to utilize research carried out by the author for assisting agronomic management of rubber plantation. Research on rainfall prediction by using SOI and rainfall with a probability of 75% [7] was used to decide the best of planting time. Observation on the timing of rainfall related to tapping activity and rainguard technique to divert stemflow was used to anticipate yield loss due to rain [8]. The study of leaf disease occurrence related to climate was developed by Munir and Thomas [9] and this could be implemented to avoid yield loss due to Colletotrichum leaf fall disease for a particular clone during La Nina years.

All the research work that had been done was synthesized to enable for implementation for agronomic management in the rubber plantation.

3. Result and Discussion

3.1. Climatic Element Observation

The most common meteorological station is using the WMO standard, where rainfall, temperature, radiation, and evaporation were measured with a rain gauge, maximum and minimum thermometer, Campbell stokes, class A pan evaporation. Now, the automatic weather station (AWS) is frequently used with the advantage of easiness in recording climatic elements. By using AWS, there no need for a person that reads the climatic element in the meteorological station, but the data can be transmitted and saved in the data logger. Also, the frequency of recording can be set for a very short period, for example reading every 10 minutes, or every 1 hour, etc. Besides that international meteorological organization provides data on sea surface temperature, the southern oscillation index that is published every 2 weeks to anticipate the El Nino or La Nina event.

3.2. Anticipation Climatic Anomaly

Rainfall is the most important climatic element and it varies with time and place. El Nino/La Nina can be predicted by examining the SOI value (Southern Oscillation Index) that is published by the Australian Bureau of Meteorology or others. SOI value is related to rainfall variation so that it is frequently used to predict rainfall.

La Nina is related to the following changes [10]:

a. The decrease of sea surface temperature along the Eastern and central tropical Pacific ocean.
b. The increase in convection or cloud development in Indonesia/Australia.
c. Continuous positive SOI values

On the other hand, El Nino is followed by rainfall decrease below normal value. During El Nino, SOI values are continuously negative.

SOI is an index that shows activities of Southern Oscillation. SOI is calculated by the formula:

\[ \text{SOI} = 10 \frac{\text{Pdiff} - \text{Pdiff}_{av}}{\text{SD}(\text{Pdiff})} \]  

where Pdiff = (average pressure in Tahiti for a particular month) - (average air pressure in Darwin for the same month), Pdiff_{av} = long term Pdiff for a particular month, SD (Pdiff) = long term standard deviation for a particular month.

Strong La Nina occurred when SOI values are greater than +10. The monthly value of SOI from 2010 to 2019 is shown in figure 1. In 2010/2011, strong La Nina can be seen and high rainfall was observed.

SOI is related to the rainfall variation and often used as a rainfall predictor. Australian Bureau of Meteorology uses SOI to predict rainfall in 2 or 3 months ahead based on the correlation between
previous 2 monthly SOI value with following rainfall [5]. For annual crops, SOI pattern can be used to predict yield in the following months [11].

Figure 1. Distribution pattern of monthly SOI from 2010 to 2019

The study of the relationship between SOI and rainfall was carried at Lampung where an average of 3 months of SOI was correlated with 3 monthly rainfall ahead. The result is shown in figure 2. It showed a significant correlation between rainfall from July to November with SOI. The value of SOI was taken from the Australian Bureau of Meteorology [10].
3.3. Use Oo Weather Data From Meteorological Station

3.3.1. The water requirement in the ground rubber nursery. The water potential water requirement crop that has fully covered the ground surface is equal to potential evapotranspiration measured with pan evaporation class A in the meteorological station. In rootstock nursery, there was a water deficit problem due to the seeding season occurred just before the dry season.

By calculating rainfall as input and evapotranspiration estimated by pan evaporation or AWS as output, therefore water needed for irrigation can be estimated, also soil can function as storage where maximum available water is in the field capacity and at wilting point plant experience severe water stress. Field capacity and wilting point can be determined in soil physic laboratory by applying pressure at 1/3 and 15 bars respectively on soil that had been saturated with water and it was placed in a pressure plate. In general, when soil water > 50% available water, the plant does not experience water stress. Irrigation is set when the available water is < 50%.

Figure 2. The relationship between previous 3 monthly SOI 3 with rainfall
3.3.2. Rainfall pattern. Besides the amount of rainfall, the rainfall distribution is also important for rubber tapping activity. Tapping was commenced in the early morning and latex collection was done in the midday. Rainfall that occurred in the morning will disturb tapping activity, while rainfall occurred during the latex collection will also disturb. Also when the latex was still dripping after collection, rainfall occurred in the afternoon also reduce yield. Figure 3 shows that rainfall frequency at Sembawa Research Centre is more in the late afternoon so that tapping activity is not disturbed too much. The risk was during the high yield, where latex is still dripping and it may be washed by late afternoon rain.

![Figure 3. Hourly rainfall distribution at Sembawa Research Centre](image)

The impact of La Nina on rubber plantation is the reduction of the number of tapping days due to morning rainfall. Sivakumaran et al. [12] stated that in a rubber plantation in Malaysia, tapping days loss could reach 71 days/years or equal to 535 kg/ha/year, and cup lump loss as much as 50%. In India, about 80 tapping day was lost due to rainfall [13].

During La Nina 2009/2010, rainfall in Sembawa Research increased dramatically. Rainfall in 2009 was 2403 mm and increase to 3,896 mm in the year 2010, also rainy day increase from 122 days to 178 days. The impact of La Nina was on the tapping day loss (table 1). The tapping days' loss was 9 days. The other impact of rainfall is the delay of the commencement of tapping. When the tapping panel was still wet at 9 am, tapping was not carried out. Basuki and Tobing [14] reported that 1 and 3 hours delay in tapping resulted in yield loss as much as 5 and 18%.

The tapping day loss and tapping delay can be overcome by rainguard technology. In India, 25 to 40 tapping days can be saved by the implementation of rainguard [13].

Rain guard has a function to divert water flow through stem so that the water was not entering into the latex cup. Rain guard reduced significantly the amount of water entering to latex cup. By using rainguard, only 20% of rainfall enter to latex cup so that the latex wash by rainfall can be minimized [15].

The amount of rainfall also determines the time of planting. By recording long term data of rainfall, it could be used for determining the time of planting. Most planters used the average of rainfall, but it might not be suitable because of rainfall variability due to climatic anomaly. For planning, it was more secure to determine the time of planting with the probability of rainfall at least 75% or the minimum of rainfall satisfied for planting was at least having chance 3 out of 4 (table 2). For example, long term data at Sembawa Research Centre showed that the average rainfall was high in...
October, but to be more certain, the planting time should be planned in November because of rainfall variability.

Table 1. The number of rainy days during La Nina and normal years

| Month   | The number of the day without tapping in 2010 (La Nina) | Total tapping days | The number of a day without tapping in 2009 (normal year) | Total tapping days |
|---------|--------------------------------------------------------|--------------------|--------------------------------------------------------|--------------------|
|         | Due to rain | Due to public holidays |                        | Due to rain | Due to public holidays |                        |
| January | 1           | 2                    | 28                     | 4           | 1                      | 26                     |
| February | 1            | 27                   | 28                     | 1           | 30                     |
| March   | 1           | 1                    | 29                     | 3           | 1                      | 27                     |
| April   | 2           | 28                   |                         | 1           | 29                     |
| May     | 1           | 2                    | 28                     | 1           | 30                     |
| June    | 1           | 29                   |                         | 1           | 29                     |
| July    | 2           | 29                   |                         | 2           | 29                     |
| August  | 1           | 3                    | 27                     | 2           | 29                     |
| September | 6           | 24                   | 27                     | 1           | 23                     |
| October | 1           | 30                   | 26                     | 1           | 29                     |
| November | 2           | 26                   | 1                      | 2           | 29                     |
| December | 1           | 1                    | 29                     | 3           | 27                     |
| Total   | 7           | 24                   | 334                    | 16          | 21                     | 328                    |

Table 2. Rainfall with a probability of 75% for determining the time of planting

| Month   | Average rainfall (mm) | Rainfall with probability 75% (mm) |
|---------|-----------------------|-----------------------------------|
| January | 221.6                 | 121.6                             |
| February | 173.9                | 116.3                             |
| March   | 311.6                 | 191.1                             |
| April   | 243.6                 | 121.6                             |
| May     | 157.1                 | 79.7                              |
| June    | 85.5                  | 24.4                              |
| July    | 101.1                 | 55.0                              |
| August  | 97.6                  | 43.1                              |
| September | 123.6               | 41.7                              |
| October | 211.3                 | 67.3                              |
| November | 299.3                | 216.0                             |
| December | 231.6                | 158.6                             |

3.3.3. Prediction of yield distribution pattern during El Nino. During the El Nino, the rubber yield in the second semester in the southern part of Indonesia is usually depressed. The yield distribution during normal and El Nino years is presented in figure 4. Figure 4 shows that the different plant age of maturity (TM2 – TM10) has a similar pattern of monthly yield distribution. It could be seen that greater yield depression in the second semester compared with in the normal year. The change of this pattern can be used for yield estimation during the El Nino years.
3.3.4. Anticipation leaf fall disease during La Nina. A climatic anomaly in 2010 (La Nina) would be more severe when tree health was disturbed due to high humidity caused by the increase of rainfall. For example, La Nina in 2010 affected the performance of BPM 24 clones in Lampung province and resulted in yield reduction compared with the normal year (figure 5). BPM 24 was not suitable for a high rainfall area (rainfall >3,000 mm/year), while the rainfall in 2010 reached 7,000 mm due to La Nina.

On normal condition, the productivity of plants for October to December 2010 was estimated by using monthly distribution and it was estimated that for 1 year, the productivity could reach 2.014 kg/ha, however, due to La Nina, the real productivity was 1,758 kg/ha. This meant that yield was lost due to La Nina was 255 kg/ha. Leaf fall in 2010 occurred because the new leaves formation was disturbed by excessive rainfall so that the secondary leaf fall occurred 4 times. Thin canopy resulted in lower photosynthesis and hence reduced yield.

Figure 4. The change of yield distribution pattern due to El Nino in 2006
Leaf disease that may occur due to high rainfall during the leaf fall and leaf formation period was Colletotrichum caused by a fungus of *Colletotrichum gloesporioides*. Continuous heavy rain would stimulate the development of C. gloesporioides [16].

Based on research findings, the attack of Colletotrichum was related to the first 10 days during the new leaf formation [17]. By observing the rainfall the attack of Colletotrichum and control could be anticipated as shown in table 3 [9].

**Figure 5.** Yield distribution of BPM 24 due to La Nina
| Disease               | Climatic condition (average first 10 days of new leaf formation) | Biological observation in the field | Forecasting | Measure control |
|-----------------------|---------------------------------------------------------------|------------------------------------|-------------|----------------|
| **Colletotrichum**    | Rainfall (mm/day)  | Rainy days  | Sunshine duration (hours/day) | Spore density in air (spore/mm²) | Attack intensity (%) | The heavy attack in the next 10 days | Applied fungicide with 1 or 2-time dosage |
| Leaf fall disease     | ≥14               | 6-8        | 3                        | >17               | >35             | 3-5                         | Applied fungicide with a low dosage |
|                       | ≥11               | 3-5        | 5                        | 9-17              | 5-35            | 9                          | No attack in the next 10 days |
|                       | <11               | <3         | >5                       | <9                | <5              | No need to apply fungicide |

| **Colletotrichum**    | Rainfall (mm/day)  | Rainy days  | Sunshine duration (hours/day) | Spore density in air (spore/mm²) | Attack intensity (%) | The light attack in the next 10 days | Applied fungicide with a low dosage |
| Leaf fall disease     | ≥14               | 6-8        | 3                        | >17               | >35             | 3-5                         | Applied fungicide with a low dosage |
|                       | ≥11               | 3-5        | 5                        | 9-17              | 5-35            | 9                          | No attack in the next 10 days |
|                       | <11               | <3         | >5                       | <9                | <5              | No need to apply fungicide |

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Fungicides that was effective to control *Colletotrichum* were mankozeb (Dithane M-45 0,2%), klorotalonil (Daconil 75 WP 0,2%), propineb (Antracol 70 WP 0,2%), karbendazim + mankozeb (Delsene MX-200, 0,2%), Copper chloride oxidet (Cupravit OB 21, 0,5%), caftafol (Difolatan 4F) [14]. Those fungicides were applied to plant by using Knapsack sprayer for rubber nursery or immature tree years 1 and 2, while Mist Blower or fogging was used in plantation with age more than 3 years old [17].

3.3.5. *Climate data used as input in crop growth simulation.* Crop models had been developing especially for food crops. Crop model simulated growth by using climatic, soil data as well as crop parameters.

For rubber, it had been developed a simple model using temperature, solar radiation, rainfall and water holding capacity of the soil [6]. The model was used especially to predict rubber growth in new areas with climatic constraints such as low temperature due to elevation, or water stress due to low rainfall.

4. Conclusion

Climate affected the performance of rubber trees. Climatic element is important to be monitored and they could be used as a tool in plantation management such as the timing of irrigation, planting, the anticipation of disease attack and crop growth simulation. La Nina and El Nino could be anticipated by monitoring the SOI pattern and it was known that La Nina was correlated with a positive value of SOI, while El Nino was the opposite. The simple correlation between 3 monthly SOI with 3 monthly ahead rainfall could be used to predict rainfall.

5. References

[1] Angus J F 1991 The evolution of methods for quantifying risk in water-limited environments In *Climatic risk in Crop production: Models and management for the semiarid tropics and tropics* Eds. Muchow R C and Bellamy J A CAB.

[2] Vanderlip, R L, Hammer, G L and Muchow, R.C 1996 Assessing planting opportunity in semiarid subtropical environments. Agricultural Systems, 51:97-112

[3] Gregory P J 1984 Water availability and crop growth in arid regions *Outlook on Agriculture* 13(4) 208-215.

[4] Meinke H, Pollock K, Hammer G L, Wang C, Stone R C, Potgieter A and Howden M 2001 Understanding climate variability to improve agricultural decision making *Proceeding of the 10th Australian Agronomy Conference*, Hobart.

[5] Nicholls N 1991 Advances in long-term weather forecasting In *Climatic risk in Crop production: Models and management for the semiarid tropics and tropics* Eds. Muchow R C and Bellamy J A CAB.

[6] Thomas 1996 Simulasi potensi pertumbuhan tanaman karet berdasarkan unsur-unsur iklim di beberapa lokasi di Maluku *Prosiding Eksposue Hasil-Hasil Penelitian Balai Teknologi Reboisasi Palembang* pp 208-217.

[7] Thomas, Lasningsih M, Junaidi U, Wibawa G, Amypalupy K dan Sihombing H 1994 Pengaruh kekeringan dan usaha mengatasiinya pada tanaman karet *Warta Perkaretan* 13(2) 1-7

[8] Wijaya T 2013 The effect of rain guard on reducing latex loss. *Journal of Material Science Engineering* 3 564-568

[9] Munir M and Thomas 2012 *Kajian dan Peramalan kejadian penyakit gugur daun Colletotrichum pada tanaman karet berdasarkan kondisi agroklimat* (Balai Penelitian Sembawa).

[10] Australian Bureau of Meteorology 2019 Easily understood El Nino and La Nina Forecast Website: http://www.bom.gov.au/climate/ahead/enso.summary.shtml.

[11] Rimmington G M and Nicholls N 1993 Forecasting wheat yields in Australia with the Southern Oscillation Index. *Australian Journal of Agricultural Research*, 44:625-632.
[12] Sivakumaran, Said, M A, Kewi, C and Choi, T Y. 1998 Rainfall as a major influencing land productivity in rubber plantations. Planters’ Bulletin. No 2. Malaysian Rubber Board
[13] Vijayakumar K R, Thomas K U and Rajagopal R 2000 Tapping In: George, P. J. and C. K. Jacob (eds). Natural Rubber: Agromanagement and Crop Processing (Kottayam-Kerala, IN: Rubber Research Institute of India).
[14] Basuki dan Tobing, H P L. 1982. Usaha memperkecil kerugian produksi akibat hujan dalam penyadapan karet. Prosiding Lokakarya Karet. PN/PT. Perkebunan wilayah I &PT4M, Medan.
[15] Thomas and Solichin M 2010 Save Every Drop of Your Latex with Rainguard (Palembang, ID: Balai Penelitian Sembawa, Pusat Penelitian Karet).
[16] Pawirosoemardjo, S 2007 “Perilaku patogen dan epidemi beberapa penyakit pada tanaman karet”. Warta Perkaretan. Vol. 26:1 27-39h.
[17] Situmorang A dan Budiman A 1990 Timbulnya epidemi penyakit gugur daun colletotrichum di perkebunan karet dan usaha pengendaliannya Kumpulan Makalah Lokakarya Nasional Pemuliaan Tanaman Karet, Pontianak. 14-17 Juli 1990.