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Investigating local climatic factors that affected pineapple production, in Lampung Indonesia

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Abstract— *In Indonesia, pineapple is one horticulture commodity which has high potential in international fruits trade, therefore the plantation should maintain its high yield and good fruit quality. One cause that determined pineapple yield was water availability even though pineapple could resist dry period. Irrigation is always needed in pineapple plantation, however, this is a costly treatment and high irrigation level has not always lead to significant increases in crop productivity. This study aimed to investigate the possible factors that determined pineapple productions in Indonesia biggest pineapple plantation in Indonesia using all climate factors available. Some statistics methods were used to utilize the available climate data to analyze the rainfall probability, rainfall frequency distribution, evapotranspiration estimation, water balance, water use efficiency and weather impacts on fruit qualities. The results showed that water from average annual rainfall should be adequate for the pineapple water needs, however there were months had water deficit and needed irrigation. Low evapotranspiration rate reflected dry soil which could be the results of high air and soil temperature. This high temperature also affected on fruit qualities. It is suggested to conduct researches on how pineapple productions and qualities that plants under shading trees.*
Keywords— ***pineapple production, rainfall probability, rainfall frequency, evapotranspiration, water use.***

I. INTRODUCTION

Pineapple [*Ananas comosus* (L.) Merr.] is the third most important tropical fruit by value after banana and citrus (Carr, 2012). The Pineapple are commercially grown in warm and humid climate, over a wide range of latitudes from 30° N in the Northern Hemisphere to 33°58′ S in the Southern Hemisphere. Pineapple grows well in tropical and subtropical climate ranging from mild coastal climate up to an altitude of about 1000 meters provided the area is free from frost. Pineapple is grown mainly for fresh, canned fruits and juice; also, it is the only source of bromelain and enzyme used in pharmaceuticals (Cahyono, Astuti and Rahmat, 2016).

Five leading pineapple producing countries are: Costa Rica, Brazil, Philippines, Thailand and Indonesia (Hossain, 2016) . World production of pineapple reached 19 million tonnes in 2008 with the industry dominated by Brazil followed by Thailand, the Philippines and Indonesia (Dhungel, Bhattarai and Midmore, 2012). One statistic report posted that leading countries in pineapple production worldwide in 2017 as in Figure 1. In Indonesia, pineapple is one horticulture commodity which has high potential in international fruits trade. Great Giant Agri-Group is an integrated plantation located in Lampung, Indonesia, operated in 32,000 Ha area and planted in large part with pineapple but also banana, cassava, guava and other fruits. This plantation company now is the third world largest pineapple producer with more than 600,000 MT fruit annually (Loekito, 2018).

Based on that good production, the climatic conditions of Indonesia must be favorable for pineapple crop. Pineapple most favourable temperature to grow is between 18 and 35°C and optimal development and better fruit quality is achieved with ambient temperature between 22 and 32°C, thermal amplitude between day and night of 8 to 14°C and relative humidity higher than 70% (Dhungel, Bhattarai and Midmore, 2012). Pineapple is generally produced under a wide rainfall range of 600 mm to more than 3500 mm annually (Zhang et al., 2016) which Indonesia rainfall could provide. However, the use of irrigation is essentially needed to guarantee and optimize the agricultural production due to its climatic restriction in terms of spatial and temporal variability of rainfall.

Indonesia receives significant rainfall year-round but experiences a wet season that peaks in January and a dry

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season that peaks in August. Dry season rainfall anomalies are spatially coherent, strongly correlated with local sea surface temperature, and tightly coupled to El Nino–Southern Oscillation (ENSO) variations in the Pacific basin (Hendon, 2003). Rainfall irregularity produces a delay in some phenological stages of the pineapple plants resulting in reduction of the fruits production, therefore, the actual crop water requirements needs to be investigated in more detail so that proper irrigation could be incorporated to its production system, especially since irrigation system for a big company is costly and high irrigation level has not always lead to significant increases in crop productivity (de Azevedo et al., 2007).

One of the main features of pineapple is its adaptation to areas of low rainfall. It differs from most other commercial crops in that it has a photosynthetic adaptation (crassulacean acid metabolism (CAM)) that facilitates the uptake of carbon dioxide (CO2) at night. This dramatically improves its water-use efficiency when it is grown under dry conditions. But in the Great Giant Agri-Group company, there has been a decrease in productivity and fruit quality, resulting in small fruits or large fruits with small-sized crowns or with a conical shape. This is disadvantageous because the crown is one of the main pineapple planting materials. It is always the goal to obtain the best fruit quality with vigorous crowns (Suwandi, Dewi and Cahyono, 2016).

One factor that strongly affected pineapple cultivation must be the local climate, for example, cultivation of pineapple in regions with high levels of solar radiation can burn the fruit, giving rise to a loss in yield or an increase in production costs (Custodio, 2016). *Penicillium funiculosum* infection is favoured by cool temperatures (16–20^{o}C) while *Chalara paradoxa* are produced under conditions of high humidity and can be dispersed by wind (Joy and Sindhu, 2012).

Based on the above reasons this study aimed to investigate some local climatic factors that affect the pineapple fruits production.

II. MATERIALS AND METHODS

The data came from the The Great Giant Agri-Group research station located in Terbangi Besar, Lampung, Indonesia (4◦ 49’15.5” S and 105◦ 15’27.4” E, 46 m asl). The texture of the soil is sandy clay with particle sizes of 52.4% sand, 2.6% silt and 45.0% clay.

2.1. Data availability:

1. Monthly rainfall 1981-2016
2. Daily maximum and minimum air temperature, humidity, wind speed and radiation 2007-2015 missing the 2013 for calculating daily evapotranspiration
3. Monthly water use from sprinkle irrigation in 2015
4. Fruit maturity (%) and plant diseases infection (scoring) and related weather record (maximum and minimum tempareture, radiation and rainfall) 2008 -2013
5. Soil temperature 2016

2.2. Data analysis

2.2.1. Rainfall analysis

2.2.1.1. The 75 % probability of exceedence

The first step in the frequency analysis is to rank all the rainfall data. After the rainfall data are ranked, a serial rank number (r) ranging from 1 to n (number of observations) was assigned. Subsequently the probability have to be determined that should be assigned to each of the rainfall depths. If the data are ranked in descending order, the highest value first and the lowest value last, the probability is an estimate of the probability that the corresponding rainfall depth will be exceeded. When data are ranked from the lowest to the highest value, the probability refers to the probability of non-exceedance. Hence the probabilities are estimates of cumulative probabilities. They were formed by summing the probabilities of occurrence of all events greater then (probability of exceedance) or less than (probability of non-exceedance) some given rainfall depth. Finally, the probabilities of exceedance have to be estimated by a chosen method which was $\left(\frac{r}{n} * 100\right)$ and in this study the 75% probability was chosen (Dirk, 2013). The results was presented in Table 1.

2.2.1.2. Normal Rainfall

Normal rainfall is an average of the precipitation values over a 30-year period. Rainfall may very often be either well above or well below the seasonal average, or "normal.".

2.2.1.3. Rainfall Frequency Distribution

A frequency distribution is an overview of all distinct values in some variable and the number of times they occur. This method was used to analyze number of certain rainfall range occured in the study area (Dirk, 2013). The frequency distribution and the histogram could be done using Excel (Table 2).

2.2.2 Evapotranspiration estimation

The CROPWAT model was developed by the Department of Land and Water Resources of FAO. CROPWAT 8.0 for Windows is a computer program for

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the calculation of crop water demand/requirements and irrigation demand/requirements based on soil, climate and crop data and using Penman-Monteith equation to estimate evapotranspiration. The input data used for calculating potential evapotranspiration are: minimum temperature (°C), maximum temperature (°C), sunshine hours (hrs), wind speed (km/day), relative humidity (%) and latitude, longitude and altitude of the study area (Clarke, 1998) (Table 3).

2.2.3. Water balance

The water balance was conducted following Thornthwaite (1957) method; and the components and steps were as below:

P = Rainfal counting with 70% probability of excedence; PET = Evapotranspirastion calculated using CROPWAT; P-PET= Difference between P and PET; APWL= Accumulation Potential Water Loss = 0, if P > PET and if P < PET (negative) then APWL on the previous month was added with the next month negative P-PET ; SWC = Soil water content= PWP + [{ (1.00041-(1.07381/(FC-PWP)}^|(APWL)|*(FC-PWP)}; AWC = Accumulation water content= SWC of a month subtracted to SWC of precious month ;AET = Actual evapotranspiration; if P> PET then AET=PET; if P < PET then AET= P + |AWC|; Finally, water surplus = P- AET-AWC and Water deficiency = AET-PET

The field capacity and welting point of the study area were measured at the soil laboratory and the results were: field capacity was 90.2 mm and permanent welting point was 67.7 mm. The result was shown in Table 4.

2.2.4. Irrigation amount in general and water use eficiency

Irrigation was applied in turn on different block area (ha); to estimate the irrigation amount in general for each month, the average irrigation and the frequent irrigation amount that applied per day on vertain month was calculated; the results was shown in Table 5.

2.2.5 The main weather factor for fruit quality

Multiple regression and correlation were statistic method used to investigate weather impact on each of the fruit qualities. This calculation is available on Excel spreadsheet.

III. RESULTS AND DISCUSSION

3.1 Rainfall analysis

The rainfall 75% probability of exceedence in Table 1 showed that from May to October rainfall that could be expected with 75% probability was under 100 mm. Pineapples can grow well under a wide range of rainfall from mean annual precipitation (MAP) 600 - 1 200 mm. However, irrigation is necessary when MAP is < 500 mm or when consecutive months of low rainfall occur (Schulze and Maharaj, 2017). Mean annual precipitation in the study area was 2021.9 mm; should be enough for pineapples growth, however, the rain did not fall evenly while pineapples is planted all year. From that rainfall data it could be predicted that irrigation would be needed from May to October.

Rainfall frequency distribution and the histogram were presented in Table 2 and Figure 2.

Roughly, 84% of rainfall felt under 400 mm/month; and the most frequent monthly rainfall was between 50 to 100 mm. In general, eventhough the total amount of rainfall was adequate for supporting pineapples growth, irrigation is still needed in this plantation.

Table.1: Rainfall 75% probability of exceedence and normal value from rainfall data 1981-2016

Months	75 % probability (mm)	Normal (mm)	Months	75 % probability (mm)	Normal (mm)
January	256.0	378.9	July	35.0	85.0
February	219.5	333.3	August	2.0	67.1
March	298.0	388.4	September	6.5	72.5
April	150.0	211.4	October	45.0	104.9
May	87.5	143.3	November	143.5	195.0
June	40.0	82.9	December	236.0	347.6

Table 2. Monthly rainfall frequency distribution (1982-2016)

Rainfall Bin (mm)	Frequency	Rainfall Bin (mm)	Frequency	Rainfall Bin (mm)	Frequency	Rainfall Bin (mm)	Frequency
0	13	250	46	450	12	700	1
50	49	300	35	500	15	750	1
100	51	350	31	550	8	800	0
150	48	400	28	600	5	More	0
200	46			650	7		

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3.2 Evapotranspiration estimation

The estimated daily evapotranspirastion for each month in the year 2008-2015 was presented in Table 3.

Table 3. Daily evapotranspiration for each month on period 2007-2015.

Months	Year							
	2007	2008	2009	2010	2011	2012	2014	2015
January	3.48	3.53	3.51	3.53	3.18	3.63	3.54	4.10
February	2.97	2.73	2.86	3.58	3.00	3.72	3.79	3.88
March	3.79	3.23	3.81	4.05	3.26	4.05	4.06	4.42
April	3.46	3.41	3.67	3.91	3.30	4.34	4.34	4.04
May	3.60	3.35	3.63	3.13	3.40	4.16	3.85	4.16
June	3.07	3.18	3.29	2.65	3.12	3.90	3.51	4.11
July	3.24	3.72	2.83	3.20	3.35	4.08	3.70	4.41
August	3.86	3.53	3.81	3.15	4.10	4.47	4.45	4.70
September	3.92	3.79	4.11	3.16	4.12	4.90	4.86	
October	4.02	3.88	3.64	3.08	3.48	4.28	4.54	
November	3.60	3.17	3.29	3.12	3.48	3.60	3.98	
December	3.17	2.97	3.49	3.17	3.19	3.22	3.37	

Crop water requirements (ETm) for high pineapple production are very different from those of most other crops. Because of crassulacean acid metabolism (CAM), pineapple is adapted to dry environments by suspended transpiration during the day (Dhungel, Bhattarai and Midmore (2012) and Carr (2012). As a result, maximum evapotranspiration is low and varies between 700 and 1000 mm per year. Data above showed that daily mean reference evapotranspiration was about 3.42 mm or about 1249 mm/year, while from the data above mean annual precipitation in the study area was 2,446.5 mm. The results was lower that that in Brazil which crop evapotranspiration was (ETc = 4.6 ± 0.5mm day-1) and reference evapotranspiration was (ETo = 5.1 ± 0.4mm day-1) (de Azevedo et al., 2007)

Carr (2012) also mentioned that over the monitored 341-day period in Brazil the potential

evapotranspiration rate (ETc) was relatively constant 4.1 ± 0.6 mm per day and ETc totalled 1420 mm and ETo 1615 mm. For the crop coefficient Kc (=ETc/ETo), in the FAO crop evapotranspiration manual, Allen et al [16] specified the following Kc values for pineapple: the initial stage, Kc = 0.50; mid-season, Kc = 0.30; end-season, Kc = 0.30 (all values assume that 50% of the ground surface is covered with black plastic mulch, as practised in Hawaii). However, for well-watered pineapple crops Kc has maximum values of 0.8–0.9. Indeed, (Souza and Reinhardt, 2007) even suggested that, for a crop with 100% ground cover, Kc = 1.0–1.2, which would appear to be excessive. Assumed this study using the Kc suggested by Carr (2012) then the crop water requirement would be about 1124 mm/year which was supplied adequately from the rainfall (2,446.5 mm/year). Again, this area should not lack of water for the crops growth if it distributed evenly through the year and if 100% of the rainfall would be utilized by crops.

The root system of pineapple is shallow and sparse. In deep soils, maximum root depth may extend up to 1m but roots are generally concentrated in the first 0.3 to 0.6 m, from which normally 100 percent of the water is extracted (D = 0.3-0.6 m). Under conditions when assumed the maximum evapotranspiration was reached (5 to 6 mm/day), water uptake started to be reduced when about 50 percent of the available soil water has been depleted (p = 0.5) (Steduto et al., 2012).

3.3 Water Balance

Based on water balance analysis (Table 4), months with surplus water were January to April and November to Desember; and months with deficit water were May to October except July. Cahyono, Astuti and Rahmat (2016) calculated the water balance at the same location using data from 30 years found similar results that deficit moths were June to October. Related to those results, it was obvious that irrigation was still a need if crops were planted on those deficit months.

Pineapple can survive long dry periods through its ability to retain water in the leaves which is used during these periods. However, the crop is sensitive to water deficit, especially during the vegetative growth period, when the size and fruiting characteristics are determined. Water deficits retard growth, flowering and fruiting. Water

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supply during this period should meet full water requirements of the crop (Dhungel, Bhattarai and Midmore, 2012).

Water deficit at flowering has a less serious effect and may even hasten fruiting and result in uniform ripening. An ample water supply at flowering will lead to vigorous stem growth and a large core which is disadvantageous when the fruit is used for canning. Frequent irrigation or rain at the time of harvest may cause deterioration of the quality of the fruit and make the crop susceptible to the fungus causing heart rot. In addition, waterlogging affects fruit quality. Where water supply is limited, mulching is practised to reduce soil evaporation and soil temperature. Dew has been found to contribute to meeting the wafer requirements of the crop (de Azevedo et al., 2007).

3. 4 Irrigation amount in general during deficit months and water use eficiency

From the standard evapotranspiration it could be assumed that crop water requirement was about 3.42 mm/day. Table 5 showed that the irrigation application was satisfied the crop water requirement. Total area irrigated from May to November 2015 was 42,103.7 ha and total irrigation was 4,235.8 m^3/ha. On one study in Queensland, Australia irrigation input during the crop period for the oxydation and control treatments was 2,524 and 2,405 m^3/ha respectively (Dhungel, Bhattarai and Midmore, 2012) ; the irrigation in the study area was higher than that at the Queensland area, could be because of lower precipitation (mean annual precipitation in the study area was 2,021.9 mm) compared to 4,250 mm in Queensland. A study of water consumption for some crops including pineapple in Thailand gave the results as follow mean annual rainfall was 832 mm and irrigation was 5,402 m^3/ha (Gheewala, 2014).

Table 5. Average Irrigation and amount of irrigation frequently applied

Month	Total area (ha)	Average irrigation (mm/day)	Most frequent irrigation (mm/day)	Month	Total area (ha)	Average irrigation (mm/day)	Most frequent irrigation (mm/day)
May	1316.95	4.36	2.95	September	8032.24	19.47	13.80
June	5489.50	15.52	11.92	October	7531.39	25.03	15.98
July	6666.81	221.53	169.16	November	5282.02	116.85	48.80
August	7784.79	20.82	11.67				

Average yield in 2015 was 62.44 ton/ha and total irrigation on that period was 4,235.8 m^3/ha; then it can be concluded that irrigation water requirement was 67.83 m^3/ton. The result was in good comparison with the irrigation water requirement for pineapple plantation in Thailand 135-326 m^3/ton in dry season and 6-67 m^3/ton in wet season (Cahyono, Astuti and Rahmat, 2016).

3.5 Efect of weather factors to fruit quality

Besides water other weather/climate factors were also important in crops production especialy the fruit quality. Statistic correlations between fruit maturity and some weather factors were shown in Table 6; and for diseases infections were in Table 7.

Table 6. Statistic correlations between fruit maturity and weather factors

	Column 1	*Column 2*	*Column 3*	*Column 4*	*Column 5*
Column 1	1				
Column 2	0.292475	1			
Column 3	-0.17027	-0.10144	1		
Column 4	0.147971	0.526875	-0.30591	1	
Column 5	-0.24557	-0.61235	0.168391	-0.55934	1

Column 1: fruit maturity; column 2: maximum air temperature; column 3: minimum air temperature; column 4: radiation intesity and column 5: rainfall.

Table 7. Statistic correlations between diseases attack and weather factors

	Column 1	*Column 2*	*Column 3*	*Column 4*	*Column 5*
Column 1	1				
Column 2	0.337658	1			
Column 3	0.123746	-0.10144	1		
Column 4	-0.18676	0.526875	-0.30591	1	
Column 5	-0.15571	-0.61235	0.168391	-0.55934	1

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Column 1: diseases attack; column 2: maximum air temperature; column 3: minimum air temperature; column 4: radiation intesity and column 5: rainfall.

For the fruit maturity, the multiple regression was 0.34 and regression was (r^2) = 0.11

The equation was Y= 49.55+ 1.240 tmax – 1.44 tmin - 0.03 radiation- 0.004 rainfall; while for diseases infections the multiple regression was 0.55488 and regression was (r^2) = 0.307891. The equation was Y= -35.88 +1.271 tmax +0.168 tmin -0.082 radiation-0.002 rainfall

In both quality factors air temperature especially the maximum temperature played important roles. In general this study site had maximum temperature 31.89 °C and minimum temperature 23.57°C; good fruit quality for pineapple is attributed to growing sites having a combination of relatively cool night temperatures, sunny days and day temperatures ranging from 21 to 29.5°C but not exceeding 32°C (Hossain, 2016). Similar to that, it is noted that optimal development and better fruit quality is achieved with ambient temperature between 22 and 32°C, thermal amplitude between day and night of 8 to 14°C and relative humidity higher than 70% (Dhungel, Bhattarai and Midmore, 2012).

Key issue concerning the cultivation of pineapple in regions with high levels of solar radiation is it could burn the fruit, giving rise to a loss in yield or an increase in production costs (by up to 11.7%) since the crop has to be protected through the provision of artificial shade. Under shade conditions, the growth and survival of a plant is closely associated with its ability to intercept light efficiently. Some species exhibit phenotypic plasticity, in that they could modify their shape and structure in response to changes in luminosity to improve photosynthetic efficiency (da Silva et al., 2017).

High temperature in the study area was also reflected on the soil temperature as presented in Table 8 (data from the year 2016), As stated above, pineapple roots are generally concentrated in the first 0.3 to 0.6 m, from which normally 100 percent of the water is extracted, on this depth the soil temperature could reach a range of 33.9 to 37.3°C. In contrast, Table 2 showed that daily mean reference evapotranspiration was about 3.42 mm much lower than that in Brazil which the reference evapotranspiration was (ETo = 5.1 ± 0.4mm day $^{-1}$) (Allen, 1998). Lower evapotranspiration indicated that the soil was dry -water was not available to be evaporated. It could also indicated that even water from rainfall and irrigation was not adequate to prevent the soil from being dry by sun radiation. Therefore, to maintain good yield and good fruit quality, from agroclimate views, irrigation should be intensified especially during months with water deficit. Regarding global warming, high air and soil temperature and probably decreasing rainfall trend could be negatively impacted pineapple production in the future. Farmers in Nsawam Adoagyiri district, Ghana considered supplementary irrigation especially during the dry months of the growing periods where rainfall is generally low (Williams et al., 2017)

Table 8. Soil temperature (°C) for morning, noon and afternoon in different depth.

Months	07.00				13.00				17.00			
Depth (cm)	0	5	50	100	0	5	50	100	0	5	50	100
January	27.7	27.3	30.3	30.1	34.5	33.5	30.2	30.1	31.8	31.9	30.3	30.2
February	27.2	27.1	29.7	29.8	33.3	32.6	29.8	29.8	31.8	31.6	29.7	29.8
March	27.9	27.9	30.2	30.1	33.5	33.8	30.2	30.1	31.1	31.5	30.1	30.1
April	27.2	27.2	29.9	30.1	34.2	34.0	30.0	30.1	31.6	32.1	30.0	30.1
May	27.4	27.3	30.2	30.1	33.7	34.1	30.2	30.2	31.6	32.3	30.2	30.1
June	26.5	26.4	29.4	29.5	33.3	33.4	29.4	29.5	31.2	31.9	29.4	29.5
July	26.4	26.5	29.2	29.3	34.5	33.8	29.2	29.3	31.9	31.8	29.2	29.3
August	26.8	26.5	29.3	29.2	37.1	34.9	29.3	29.2	33.9	33.5	29.3	29.2
September	27.1	27.1	29.8	29.7	37.3	35.2	29.8	29.7	33.6	33.7	29.8	29.7
October	27.0	26.9	29.2	29.3	32.7	31.9	29.2	29.3	30.8	30.8	29.2	29.3
November	27.4	27.3	29.4	29.4	33.3	31.8	29.4	29.4	31.3	31.0	29.4	29.4
December	27.7	27.6	29.8	29.4	33.7	32.7	29.7	29.4	32.2	31.7	29.7	29.4
Maximum	**27.9**	**27.9**	**30.3**	**30.1**	**37.3**	**35.2**	**30.2**	**30.2**	**33.9**	**33.7**	**30.3**	**30.2**
Minimum	**26.4**	**26.4**	**29.2**	**29.2**	**32.7**	**31.8**	**29.2**	**29.2**	**30.8**	**30.8**	**29.2**	**29.2**

Lampung Province produces about 32.77% from all pineapple production in Indonesia and 99.71% is planted in Central Lampung. Most of Central Lampung is a flat lowland area (25 -75 m asl) and pineapple plantation is a large open area without any trees; this could be the reason of hot and dry environment. Some smaller pineapple plantations in Indonesia is located in hills area and with shading trees, however, most common is in an open area of lowland (Pusat data dan sistim informasi pertanian, 2016). An experiment of planting pineapple under shade conditions in Brazil resulted that under normal light conditions, the rate of synthesis and degradation of chlorophylls of plants under direct sunlight and under shading was the same, but degradation can be accelerated by excess solar. The thicker aquiferous hypodermis detected in nonshaded plants might function as a filter to protect chlorophyllous tissue from intense radiation, thereby reducing the level of chlorophyll degradation. Moreover, no significant differences regarding yields or mean masses of pineapple fruits were detected between treatments. However, the percentages of sunburned fruits were significantly higher under direct sunlight treatment (da Silva et al., 2017).

IV. CONCLUSION

This study did not aim to solve all problems in this pineapple plantation since other factors: soil and cultivation management factors that important in pineapple cultivation were not included. High air and then soil temperature seemed to be the critical factor that needed to manage. Researches on how pineapple productions and qualities under shading trees should be considered in the future especially in general it is predicted that air temperature might increase.

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Table 4. Water balance based on Thornthwaite and Matter

No	Code (mm)	Months												Anual
		Jan	Feb	March	April	May	June	July	August	Sept	Oct	Nov	Dec	
1	Precipitation	314.8	357.0	388.3	222.0	80.0	83.3	154.3	70.5	71.0	105.8	182.3	222.0	2251.0
2	PET	103.4	90.8	108.8	106.5	102.7	91.9	98.0	110.7	114.6	108.6	100.0	96.0	1231.9
3	P-PET	211.4	266.2	279.4	115.5	-22.7	-8.6	56.2	-40.2	-43.6	-2.8	82.3	126.0	1019.1
4	APWL	0.0	0.0	0.0	0.0	-22.7	-31.3	0.0	-40.2	-83.9	-86.7	0.0	0.0	
5	SWC	90.2	90.2	90.2	90.2	133.0	165.6	90.2	216.8	1228.1	1392.2	90.2	90.2	
6	AWC	0.0	0.0	0.0	0.0	42.8	32.6	-75.4	126.6	1011.3	164.1	-1302	0.0	
7	AET	103.4	90.8	108.8	106.5	122.8	115.8	98.0	197.1	1082.3	269.9	100.0	96.0	2491.4
8	Water Surplus	**211.4**	**266.2**	**279.4**	**115.5**	0.0	0.0	**131.6**	0.0	0.0	0.0	**1384.3**	**126.0**	2514.4
9	Water Deficiency	0.0	0.0	0.0	0.0	*-20.1*	*-24.0*	0.0	*-86.4*	*-967.6*	*-161.3*	0.0	0.0	-1259.4