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Jurnal Agroteknologi
Journal homepage: https://jaet.usu.ac.id

The Influence of Climate Elements to Tea Plant Productivity (*Camellia Sinensis*L.) At Bah Butong Plantation PTPN IV 2005-2009

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ARTICLE INFO
Article history:
Received : 10 Januaray 2024
Revised : 15 April 2024
Accepted 06 May 2024
Available online
https://talenta.usu.ac.id/joa

E-ISSN: 2356-4725
P-ISSN:2655-7576

How to cite:
Aditya, J, S. (2024). The Influence of Climate Elements to the Productivity of Tea Plants (Cammelia sinensis **L.**) at Bah Butong Plantation PTPN IV 2005-2009. Jurnal Agroteknologi 12(2), 01-07

http://doi.org/ 10.32734/ja.v12i2.18761

ABSTRACT
Fluctuations in tea plant productivity are influenced by several climate factors, such as rainfall, number of rainy days, sunlight intensity, temperature and humidity. This research aims to evaluate the impact of climate factors on the productivity of Tea plants in the Bah Butong Plantation of PT. Perkebunan Nusantara IV, Simalungun Regency, North Sumatra. The hypothesis of this research is that rainfall, number of rainy days, sunlight intensity, temperature and humidity partially or simultaneously have a significant influence on the productivity of tea plants at the location. The research was conducted from September 2023 – December 2023, with data collection through field surveys and secondary data collection from related agencies. The data collected includes rainfall, number of rainy days, sunlight intensity, temperature, humidity and tea. The analysis method used is multiple linear regression and correlation analysis using statistical software SPSS.v.22 for Windows. The results of the regression analysis show that rainy days and temperature do not have a partially significant effect on increasing tea production. However, rainfall, amount of sunlight, humidity have a significant effect on increasing tea production. The results of the regression analysis show that rainfall, number of rainy days, sunlight intensity, temperature and humidity do not have a significant influence on increasing tea production.
Keywords: Climate, Tea Productivity, Tea

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Fluctuations in tea plant productivity are influenced by several climate factors, such as rainfall, number of rainy days, sunlight intensity, temperature and humidity. This research aims to evaluate the impact of climate factors on the productivity of tea plants in the Bah Butong Plantation of PT. Perkebunan Nusantara IV, North Sumatra. The hypothesis of this research is that rainfall, number of rainy days, sunlight intensity, temperature and humidity partially or simultaneously have a significant influence on the productivity of tea plants at the location. The research was conducted from September 2023 – December 2023, with data collection through field surveys and secondary data collection from related agencies. The data collected includes rainfall, number of rainy days, sunlight intensity, temperature, humidity and tea production. The analysis method used is multiple linear regression and correlation analysis using statistical software SPSS.v.22 for Windows. The results of the regression analysis show that on rainy days, temperature does not have a partially significant effect on increasing tea production. However, rainfall, amount of sunlight, humidity have a significant effect on increasing tea production during the period. The results of the regression analysis show that rainfall, number of rainy days, sunlight intensity, temperature and humidity do not have a significant influence on increasing tea production..
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1. INTRODUCTION

Originating from subtropical areas, the tea plant is one of the most valuable plantation crops in Indonesia and is used as a raw material for drinks. The country's non-oil economy can generate a sizable increase in foreign currency through sales of processed goods from these businesses. The Central Bureau of

Statistics (2014) reported that the value of tea plants shipped in 2013 was $177,498,000 USD. The result was $710,000 USD less than the previous year. Low plant productivity is one of the problems faced by the tea agroindustry in Indonesia and contributes to a decline in plant productivity (Sudjarmoko, 2014).

According to research by Utomo et al. (2018), the growth rate is not significantly influenced by partial and simultaneous climate factors, and there is a poor correlation between the increase in tea production on the Sidamanik plantation during the 7 year period (2010-2016). 95% confidence level. Simalungun Regency in North Sumatra is home to PT. Perkebunan Nusantara IV.

The climate conditions in the Tobasari plantations have a large relationship to the increase in tea production over the ten year period (2011-2020) and have a low influence, at the 95% confidence level, according to a study conducted by Harahap et al. (2021). Simalungun Regency in North Sumatra is home to PT. Perkebunan Nusantara IV.

One strategy to overcome poor plant results in tea cultivation is to use better tea seeds. Superior seeds can be developed through vegetative propagation. Clonal plant material derived from cuttings is often used in vegetative propagation (Setyamidjaja, 2010).

Indonesia has a lot of potential to develop tea, an important staple crop and plantation product. Although Indonesia's main economic growth strategy is to increase non-oil and gas exports, tea exports still constitute a small part of agricultural exports. Black tea or North Sumatran tea is still not profitable.

Indonesia produces two main types of tea: green tea and black tea. This term refers to various types of unfermented tea. Since the 18th century, Indonesia has experienced a sharp increase in the tea agro-industry, which is recognized as a major source of foreign exchange profits for the country's economy. The main source of foreign currency earnings is the tea industry. Indonesia is ranked sixth in the world and exports 70% of the tea produced worldwide. The tea is taken abroad. South Korea, Japan, Europe, America and South Korea are the destinations for Indonesian tea exports.

Rainfall is a meteorological factor that influences tea production. The risks posed by adverse weather patterns and rising temperatures to tea plants were emphasized by Setyamijaja (2000). Tea plants grow best in climates with an average temperature of 180–230 degrees Celsius, annual rainfall of 2,000–2,500 millimeters, and a minimum altitude of 1,200 meters above sea level. If the required amount of rainfall is not received, tea yields will decrease by 15% to 25% (Ali et al., 2014). The Tea and Cinchona Research Center (2006) states that temperatures that are too high or too low for tea plants to thrive are less than 130°C or more than 300°C.

Based on the facts above, scientists are curious to find out more about the influence of climate on the yield of tea plants at PT. Perkebunan Nusantara IV Bah Butong Plantation is located in Simalungun Regency, Pematang Sidamanik Regency, North Sumatra.

2. MATERIALS AND METHODS

This research was carried out in the Bah-butong plantation of PT. Perkebunan Nusantara IV, Pematang Sidamanik District, Simalungun Regency, Sumatra Province, precisely at the coordinates 20 51' 34.5" N – 980 54' 17.7" E and an altitude of 910 meters above sea level, with a land area of 1,884,526 Ha. This research was carried out from September to December 2023.

The analytical method used in this research is multiple linear regression analysis and correlation. Multiple linear regression analysis techniques are used to determine the functional influence of two or more independent variables on the dependent variable, and correlation analysis is useful for seeing the strength and weakness of the relationship between the independent and dependent variables. The dependent variable is a variable whose existence is influenced by the independent variable and is denoted by Y. The dependent variable in this study is tea productivity, while the independent variable is the variable that influences or is the cause of the change in the dependent variable and is denoted by X. The independent variable in this study is monthly rainfall and rainy days, amount of sunlight, temperature and humidity. Data processing was assisted by SPSS.v.22 for Windows software.

The functional influence of rainfall, monthly rainy days, amount of sunlight, temperature and humidity on tea productivity using the following equation model:

$$Y = a + b1X1 + b2X2 + b3X3 + b4X4 + b5X5 + \varepsilon$$

Information :

Y : Tea productivity
a : Intercept and line on the Y axis
b : Linear regression coefficient
X_1 : Rainfall
X2 : Rainy day
X3 : The amount of sunlight
X_4 : Temperature
X_5 : Humidity
ε : error

2.1. Determining Research Locations

The research location, which is located on the PT Bah Butong plantation, was selected using a purposive sampling technique. Perkebunan Nusantara IV in North Sumatra Province, in Simalungun Regency, Pematang Sidamanik Regency. The research location was selected by searching the Bah Butong plantation office to find out overall production statistics for Afdeling I, t II, Afdeling III, and Afdeling IV in order to obtain a basic concept of the area to be studied. PT. North Sumatra Province. Perkebunan Nusantara IV is located in Pematang Sidamanik District, Simalungun Regency.

2.2. Literature Study

To conduct a literature study, a search and review of previous research was carried out on rainfall, rainy days, sun exposure, humidity, temperature and tea production in general.

2.3. Data collection

Secondary data for general reporting and secondary data that is processed for analysis are included in the collection of processed secondary data. Monthly reports from the plantation office of PT Bah Butong, Perkebunan Nusantara IV, Simalungun Regency, North Sumatra, are the source of secondary data that is processed. General company profile, location, plantation area, production conditions and factory productivity are some of the data used for general reports. Monthly data for the five years 2005, 2006, 2007, 2008, and 2009 include rainfall (mm), rainy days (days), amount of sunlight (hours), temperature (oC), humidity (%), and productivity (kg/ ha/month) processed as secondary data for this research.

2.4. Data Management and Data Analysis

By initially checking conventional assumptions, SPSS.v.22 software for Windows helps in data processing. This test helps determine whether it is necessary to test the secondary data collected. The hypothesis that has been tested will become a conclusion after the data that is suitable for testing is further examined using multiple linear regression analysis and correlation analysis, and compared with the initial hypothesis. This is a test run using secondary data.

The tests carried out on secondary data are as follows:

2.5. Classic assumption test

The classical assumption test is a useful method for determining whether the regression model used in research is appropriate. Regularly distributed result data and the absence of multicollinearity, heteroscedasticity and autocorrelation in the model are prerequisites for the regression model to be applied. Analytical models can be used when all these requirements are met.

2.2.1 Normality Test

The purpose of the normality test is to ensure whether the independent and dependent variable data in a regression model is distributed regularly or not. Normal distribution of data prevents excessive levels, which can further distort research findings. High-quality regression models have normal or near-normal data distribution. The Kolmogorov-Sminov one sample test with a significance level of 0.05 will be used in this discussion. If the Kolmogorov-Sminov test result for one sample is more than 5% or 0.05, this indicates that the data sample, if significant, has a regular distribution.

2.2.2. Heteroscedasticity Test

By using inequality of variance and residuals from one observation to the next in the regression model as a traditional assumption of heteroscedasticity, the heteroscedasticity test determines whether there are deviations from this assumption. The absence of symptoms of heteroscedasticity, which is often referred to as homoscedasticity, is a condition that must be met by the regression model. The Glejser test is the testing methodology used. Absolute residual values were regressed against additional independent variables using the Glajser test. Heteroskedasticity in the model is indicated if the β value is large enough.

2.2.3. Multicollinearity Test

The multicollinearity test aims to find out whether the independent variables in the regression model have a linear relationship with each other. Lack of multicollinearity is one of the conditions that must be met by the regression model. The variance inflation factor (VIF) value and tolerance value of the regression model were examined to carry out a multicollinearity test. The regression model with multicollinearity and a VIF score of 0.1 was considered very good.

2.2.4. Autocorrelation Test

To determine whether the remaining observations change as more data is added to the regression model, an autocorrelation test is used. You can compare the Durbin Watson (d) values with the Durbin Watson table values to see if there is autocorrelation. The regression model must be free of autocorrelation so that the requirements are met. Durbin-Watson test procedure, or DW test, in the following circumstances:

- If $dU < 4\text{-}dU$ then H0 is accepted, meaning there is no autocorrelation.
- If $dW < dL$ or $dW > 4\text{-}dL$ then H0 is rejected, meaning autocorrelation occurs.
- If, $dL < dW < dU$ or $4\text{-}dU < dW < 4\text{-}dL$, then it cannot be concluded.

2.6. Hypothesis test

The hypothesis was tested using the partial t test, simultaneous F test, and R2 based on suggestions. A two-way test was carried out with a significance level (α) set at 5% to determine whether a hypothesis was accepted or rejected. The coefficient of determination (R2) describes how much influence the independent variable has on the value of the dependent variable. An R2 number that is close to zero indicates that all independent factors have a smaller impact on the value of the dependent variable, while a value that is close to one indicates that all independent variables have a larger impact.

Partial hypothesis testing is used to determine the proportional contribution of each independent variable to the dependent variable. To perform this test, t tables and calculated t values are compared. Simultaneous hypothesis testing is used to ensure the overall influence of the independent variables on the dependent variable. The estimated F value and the table F value are compared in this test. We propose the following theoretical framework:

H0: bi = 0

Hi : bi ≠ 0,

Bi = regression coefficient of the ith variable

Decision making to determine whether the hypothesis H0 is accepted or rejected. The failure to accept the hypothesis H0 indicates that independent factors greatly influence tea plant production.

2.7. Drawing Conclusions

An overview of data processing findings from many linear regression and correlation studies is given in the conclusion. A hypothesis may provide clues about its truth even if the hypothesis is rejected or accepted.

3. RESULTS AND DISCUSSION

Table 1. Average tea productivity (kg/ha), average rainfall (mm), and average rainy days (days), average amount of sunlight (hours), average temperature (°C), average humidity (%) on tea plants for 5 years (2005-2009).

Month	Average					
	Rainfall (mm)	Rainy day (day)	Amount of sunlight (hours)	temperature (°C)	Humidity (%)	Production (kg/ha/month)
January	232.2	10.6	242.4	21.94	88.4	1,533,612
February	149.8	8.8	300	22.38	85.4	1,496,140
March	253	14.4	280.8	22.56	87.2	1,517,126
April	319.4	14.4	278.4	22.96	87.2	1,471,476
May	220.4	10.4	288	23.34	85.2	1,490,800
June	171.2	8.8	286.8	23.12	84.8	1,538,555
July	218.2	8.6	289.2	22.96	83.8	1,564,100
August	200.2	10.2	298.8	22.74	85	1,475,230
September	189.2	11.2	286.8	22.78	85.4	1,606,880
October	347.8	15.2	237.6	22.44	88	1,581,100
November	305	15	206.4	22.18	89.9	1,599,500
December	288.2	14.2	198	21.94	89.8	1,565,480
Total	232.2	10.6	242.4	21.94	88.4	1,533,612
Average	149.8	8.8	300	22.38	85.4	1,496,140

From Table 1 it shows that the highest average tea productivity over 5 years was in September, namely:1,606,880 kg/ha/month and the lowest average was in April, namely 1,471,476 kg/ha/month. The highest average rainfall over 5 years was in October, namely 347.8 mm/month and the lowest average was in June, namely 149.8 mm/month. The highest average of rainy days over 5 years was in October, namely 15.2 days/month and the lowest average was in July, namely 8.6 days/month. The highest average amount of sunlight over 5 years was in February, namely 300 hours/month and the lowest average amount of sunlight over 5 years was in December, namely 198 hours/month. The highest average temperature for 5 years was in May, namely 23,340C and the lowest average was in January and December, namely 21,940C. The highest humidity average over 5 years was in November, namely 89.9%, and the lowest average was in July, namely 83.8%.

3.1 Multiple Linear Regression Analysis

Table 2. Coefficient values of multiple linear regression equations on tea plants. for 5 years (2005-2009)

Model	Coefficient Value		
	R	R2	Adjusted R Square
1	.826a	,687	,426

The multiple linear regression equation for five years of research on tea plants has an adjusted coefficient of determination (Adjusted R2) of 42.6% and a coefficient value (r) of 82.6% based on the collected results. The coefficient value (r) of 82.6% indicates a good relationship between these factors and tea plant productivity. 68.7% of the variation in tea production may be caused by differences in rainfall, wet days, sunlight, temperature, and humidity, according to the coefficient of determination (R2). This difference may be caused by other things that are not caused by the model. the remaining 31.3 percent.

Table 3. Partial t test for climate elements on tea plants for 5 years (2005-2009)

Observation Variables	5 years	
	t-count	Sig.
Rainfall	-1,220	,029
Rainy day	1,872	,110
Length of Sunlight	-3,192	.019
Temperature	-.944	,381
Humidity	-2,500	,047

The variable rainfall on tea plants over a five year period has an alpha significance value of less than 5% (sig<α 0.05), or more specifically 0.029<0.05, based on the findings of the partial t test. Apart from that, the projected t value is greater than the table t value (-1.220 > 2.201). Therefore, it can be concluded that the t count is very significant at the 95% confidence level (H0 is rejected, Ha is accepted). Thus, rainfall is the main element that influences the amount of tea produced.

The variable rainy days on tea plants for five years has a significance value of more than alpha 5% (sig>α 0.05), namely 0.100>0.05 based on the findings of the partial t test. Apart from that, the projected t value is greater than the table t value (1.872>2.201). Therefore, it can be concluded that the calculated t has no real influence at the 95% confidence level (H0 is accepted, Ha is rejected). As a result, the partially wet day variable does not have a real impact on tea production.

Based on the results of the partial t test, the estimated t value is greater than the t table value (namely -3.192 > 2.201), and changes in the quantity of sunlight received by tea plants over a five year period have a greater influence. impact. Significant values are compared with alpha 5% (sig<α 0.05) or 0.019<0.05. Therefore, it can be concluded that the t count is very significant at the 95% confidence level (H0 is rejected, Ha is accepted). As a result, changes in sunlight have a major impact on the amount of tea produced.

The findings of the partial t test show that the tea plant temperature variable over a five year period has a significant value higher than alpha 5% (sig<α 0.05), namely 0.381<0.05. Apart from that, the projected t value is greater than the table t value (-0.994>2.201). Therefore, it can be concluded that the calculated t has no real influence at the 95% confidence level (H0 is accepted, Ha is rejected). The way tea is brewed is not significantly affected by slight changes in temperature.

The tea plant humidity variable over a period of five years has a significance value of more than alpha 5% (sig<α 0.05), or 0.047<0.05, based on the findings of the partial t test. Furthermore, the expected t value (namely -2,500>2,201) is greater than the t value shown in the table. Therefore, t count has the right effect (H0 is rejected, Ha is accepted) at the 95% confidence level. As a consequence, factors related to humidity have a significant impact on tea preparation.

Table 4. Analysis of the variance of multiple linear regression equations on tea plants for 5 years (2005-2009)

Source Diversity	Degrees Free	Amount Square	Square Middle	F count	Sig.
Regression	5	1757697000715	3513930.014	2,632	.135b
Residual	6	8001087524936	1335145.875		
Total	11	255805753209			

Based on the estimated tea plant production model for 2005-2009, the calculated F value <F Table was obtained with a significance value in the F test lower than Alpha 5% (Sig < α 5%) 0.135 < 0.05. Therefore, it can be concluded that calculated F has no significant effect on the results at the 95% confidence level (H0 is accepted, Ha is rejected). This shows that during the five year period (2005-2009), the variables in the regression model representing rainy days, temperature, humidity, sunlight and rainfall had little influence on tea output at the Bah Butong PT plantation in Perkebunan. Archipelago IV.

Table 5. Test model for multiple linear regression analysis on tea plants for 5 years (2005-2009)

Model	Coefficient
Constant	8540993.790
Rainfall	-567,807
Rainy day	25461.246
Amount of Sunlight	-2941,980
Temperature	-47191.197
Humidity	-61349.464

Based on the analysis findings, a regression equation that predicts tea production over the next five years can be created using the variables rainfall, rainy days, sun exposure, temperature, and humidity:
$\hat{Y}$=8540993.790-567.807(Rainfall)+25461.246(Rainy Days)-2941.246(Amount of Sunlight)-47191.197(Temperature)-61349.464(Humidity)+ ε

3.2. Correlation Analysis

Table 6. Correlation analysis of tea plants for 5 years (2005-2009)

Variable	Statistics Test	Bulk Rain	Day Rain	Amount Ray Sun	Temperature	Humidity	Productivity Plant Tea
Rainfall	r (coefficient)	1	,896**	-.681*	-.311	,722**	,261
	Sig.	-	,000	,015	,325	,008	,412
Rainy day	r (coefficient)	,896**	1	-.666*	-.404	.804*	,278
	Sig.	,000	-	.018	,193	,002	,381
Number of Rays Sun	r (coefficient)	-.681*	-.666	1	,733**	-.916**	-.556
	Sig.	,015	.018	-	,007	,000	,060
Temperature	r (coefficient)	-.311	-.404	,733**	1	-.779**	-.354
	Sig.	,326	,193	,007	-	,003	,258
Humidity	r (coefficient)	,722**	.804**	-.916**	-.779**	1	,039
	Sig.	,008	,002	,000	,003	-	,281
Productivity Tea	r (coefficient)	,261	,278	-.556	-.354	,339	1
	Sig.	,412	,381	,060	,258	,281	-

Note: ** = very significantly different at the 1% test level
* = significantly different at the 5% test level

Between 2005 and 2009, a correlation study of wet days and rainfall (0.896) was conducted on tea plants. This is indicated by a significance value of less than 5% (Sig < α 0.05). A study looking at the relationship between rainfall and sunlight duration on tea plants from 2005 to 2009 revealed a substantial correlation of -0.681 between the two factors. This is indicated by a significance value of less than 5% (Sig< α 0.05). Experiments conducted from 2005 to 2009 on the relationship between rainfall and temperature in tea plants showed a weak correlation of -0.311. This is indicated by a significance value of less than 5% (Sig > α 0.05). Between 2005 and 2009, research on the correlation between rainfall factors and tea plant humidity found a significant relationship (r = 0.722). This is indicated by a significance value of less than 5% (Sig < α 0.05). For tea plants planted between 2005 and 2009, the relationship between production characteristics and rainfall was not very strong (r = 0.261). This is indicated by a significance value of less than 5% (Sig>α 0.05). Correlation research on tea plants between 2005 and 2009 showed a relationship of -0.666 between sunlight and rainy days. This is indicated by a significance value of less than 5% (Sig< α 0.05). From 2005 to 2009, research on tea plants found a significant relationship (-0.404) between temperature and rainy days. In a correlation study on tea plants conducted between 2005 and 2009, a substantial relationship (r = 0.804) was found between humidity levels and rainy days; this is indicated by a significance value of less than 5% (Sig > α 0.05). This is indicated by a significance value of less than 5% (Sig< α 0.05). From 2005 to 2009, there was a negligible relationship (r = 0.278) seen in the data between tea production and wet days on tea plants. This is indicated by a significance value (Sig > α 0.05) greater than 5%. From 2005 to 2009, association studies on tea plants showed a substantial correlation (r = 0.733) between temperature and hours of sunlight. This is indicated by a significance value of less than 5% (Sig< α 0.05). There is a significant relationship of -0.916 between the humidity variable and the amount of sunlight received by tea plants, based on research on plants conducted between 2005 and 2009. This is indicated by a significance value of less than 5% (Sig < α 0.05) . With a score of -0.556, the correlation study shows a substantial relationship between variations in the quantity of sunlight received and tea plant production between 2005 and 2009. A significance value (Sig > α 0.05) greater than 5% indicates this. High negative relationship (-0,779) was found between humidity and temperature in a correlation study carried out on tea plants between 2005 and 2009. A significance value of less than 5% (Sig< α 0.05) indicates this. A 2005–2009 tea plant correlation study found a very small relationship (-0.354) between temperature and tea yield. A significance value (Sig > α 0.05) greater than 5% shows this. Correlation studies on tea plants from 2005 to 2009 showed a very poor relationship (0.039) between humidity factors and tea production. A significance value (Sig > α 0.05) greater than 5% shows this.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1. Conclusion

1. Rainfall, sunlight intensity and air humidity have a partially significant effect at the 95% confidence level on increasing tea productivity. , while rainy days and temperature have an insignificant effect at the same 95% confidence level.
2. At the 95% confidence level, the combination of rainfall, rainy days, sunlight, temperature and humidity does not have a significant effect on increasing tea production.
3. The variables rainfall, rainy days, temperature and air humidity have a significance value of more than 5% (Sig > 0.05). The significant value of each variable above 5% (Sig > α 0.05) indicates a fairly high relationship between the quantity of sunlight and tea production between 2005 and 2009. The following variables accounted for 82.6% of the variation in tea production: humidity, temperature , solar strength, rainfall, and wet days.

4.2. Suggestion

Further studies need to be carried out using additional agroclimatological elements and characteristics of agronomic measures. Additionally, the data used covers a larger time span, thereby ensuring reliable analytical findings.

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