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Effect of climatic factors on the level of Coffee berry borer (*Hypothenemus hampei* Ferr) attack on smallholder coffee plantation in Tana Toraja Regency

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Abstract. This study aims to analyze the relationship between climate parameters and the level of Coffee berry borer (CBB) (*Hypothenemus hampei* Ferr) pest attack and predict the impact of climate change on the CBB pest population. The research was conducted in Tana Toraja Regency, Gandang Batu Sillanan District, Benteng Ambeso Village and Gandang Batu Village from June 2019 to July 2019. The research was in the form of survey (literature study, observation, and interviews), with purposive sampling carried out by selecting 30 respondents as the sample. Data analysis was conducted using SPSS multiple linear regression software with five variables. The area of CPB attack was the independent variable, while the maximum temperature, minimum temperature, average temperature, humidity and rainfall were the dependent variables. The multiple linear regression equation is Y = 544.292 - 7.321X1 - 15.960X2 + 24.739X3 - 356X4 + 0.005X5. The coefficient of determination obtained was an R square value of 0.609, meaning that 60.90% of the area of the CBB pest attack for coffee plants can be explained by climatic factors, while the remaining 30.10% is explained by other variables outside the variables used. Climatic factors that affect the area of CBB pest attack were minimum temperature (probability value 0.041<0.05) and the average temperature (probability value 0.027<0.05). These variables were considered to have a significant effect while the maximum temperature factor (probability value 0.121> 0.05), humidity (probability value 0.221>0.05) and rainfall (probability value 0.581>0.05) was declared to have no significant effect.

Introduction

Indonesia is the fourth largest coffee producing country, after Brazil, Vietnam and Colombia. The types of coffee produced by Indonesia are Arabica and Robusta coffee, with total production reaching 650,000 tons per year, consisting of 81.2% Robusta coffee and 18.8% Arabica coffee. Several Indonesian coffees have been known internationally, including Aceh (Gayo), North Sumatra (Mandailing), South Sulawesi (Toraja), and Bali (Kintamani) [1].

The opportunity to increase the productivity of Indonesia's coffee plants is still wide open because Indonesia has a tropical climate which is agronomically very suitable for the cultivation of both types of Arabica and Robusta coffee plants. The productivity of coffee plants is also very likely to increase the productivity of coffee plants in Indonesia, only about 50% of the potential that can be achieved [2].

Based on data from the Statistics Agency and the Directorate General of Plantation [3, 4], the area of coffee planted in Indonesia in the 1980-2017 period tends to increase. In 1980 the area of Indonesian coffee plantations only reached 707,464 ha. In a period of two years, the area of coffee plantations increased 74.33% to 1,233,294 ha. Even so, the average growth rate of coffee acreage in Indonesia for the period 1980-2017 was not too high, it only increased by an average of 1.61% per year or increased by 14.212 ha / year.

South Sulawesi Province as one of the Arabica coffee plantation areas with the status of smallholder plantations contributes to coffee in Indonesia and has the best coffee plantation assets in Indonesia from the two types of Arabica and Robusta coffee plants. South Sulawesi coffee plantations were concentrated in several districts, namely Enrekang, Tana Toraja, Gowa, Bantaeng, Sinjai and Bone. This area is geographically very good for the development and increase of coffee production in the province of South Sulawesi. Efforts to increase coffee production in South Sulawesi are constrained by several factors, including old plants and plant pests such as coffee borer [5, 6].

The commodity coffee commodity on the Indonesian economy is quite influential in addition to other plantation commodities such as oil palm, cocoa, rubber and tea. The coffee commodity is a very large foreign exchange earner for the Indonesian state. The total national production of Indonesian coffee in 2013 was 698,887 tonnes, which came from the production of 669,064 tonnes (95.73%) of smallholder plantations involving 2.33 million households, 13,820 tonnes (1.98%) of state plantations and private plantations. 16,002 tons with an export value of USD1,174,029,129. This achievement became Indonesia's infrastructure country to deliver the largest coffee in the world in 2014 after Brazil, Vietnam and Colombia [7].

The achievement of coffee production targets must be supported by various supporting factors such as increasing the area of planting, use of superior variety seeds / seeds, application of appropriate cultivation technology, government intervention through rehabilitation activities, and empowerment of farmers. The impact of climate change in the CBB indicates the impact of a secondary pest explosion (resurgence) which can reduce crop productivity. The strategy for anticipating and adapting to climate change and attack by pests and diseases is one of the aspects that must be the strategic plan of the Department of Agriculture in the future. This is done to address the impacts of climate change on agricultural productivity. Efforts to develop a climate information system are needed as a form of adaptation to the impacts of climate change from an early age in implementing more effective pest and disease control measures [8].

Various studies show that agricultural production is subject to climate change [9]. This is between the incidence between the occurrence of climatic events and the increasing temperature exceeding the optimum conditions for plant growth [10]. Climate change itself is an event, among others, by rising temperatures, variations in rainfall, and extreme climatic events. This condition causes plant productivity in areas with higher temperatures due to heat stress, soil erosion, and land degradation due to the degree and duration of drought [11, 12].

Changes have an impact on various aspects of life, including in the agricultural sector, which is the source of the economy for most people in rural climates. The results of the climate projection planning simulation results assume the impact of climate change will be more severe in tropical areas which generally occur during the food crisis. Increasing the frequency of the climate increases the increase in abiotic and biotic stresses of plants [13].

The main problems in smallholder coffee plantations are low productivity and quality that does not meet export standards. The low productivity of coffee is caused, among others, by attacks by Plant Pest Organisms (OPT). The accumulation of these problems causes coffee plants to be vulnerable to attack by Plant Pest Organisms and exacerbated by climate change and extreme climate anomalies which ultimately result in production losses. The plant-disturbing organisms that mostly attack coffee plants are the coffee fruit borer (CBB). Apart from attacking the coffee beans in plantations, these pests can attack the coffee beans while they are stored. The CBB pests cause a significant decrease in productivity and yield quality. Attacks at the young fruit stage can cause fruit miscarriage before ripe, while attacks at ripe (old) fruit stage cause the seeds to become hollow, resulting in a decrease in weight and quality [14].

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Tana Toraja Regency is one of the areas of South Sulawesi which has the potential for the development of Arabica coffee because of its large area of cultivation due to its very supportive environmental and agro-climatological conditions. One of the best types of Arabica coffee in the world, which is only produced in Tana Toraja district, has been widely known abroad under the name Tana Toraja specialty coffee (Toraja Spescialty Coffee) and has obtained a Geographical Indication (GIS) certificate in 2013. Since several years ago, Toraja coffee have been exported to foreign countries at quite high prices, such as Germany, Japan and America. This coffee is favored abroad because of its very distinctive taste and aroma [15].

Understanding the development of pests, one of which is an understanding of the life cycle of pests and their relation to environmental factors, is important. By knowing the life cycle of pests associated with the climate in the region, it is hoped that it can assist in managing and controlling CBB pests in Indonesia. Studies on the influence of climate on CBB pests need to be carried out. Anticipation strategy and adaptation technology to climate change and pest attack is one aspect that must be a strategic plan to address climate change. Thus this research is expected to be able to contribute to suppressing the decline in production and crop failure due to CBB pests.

2. Methodology

2.1. Research time and location

This research took place from June 2019 to July 2019. This research was conducted in Tana Toraja Regency, Gandang Batu Sillanan District, Benteng Ambeso Village and Gandang Batu Village. The Gandang Batu Sillanan District has an area of 108.63 Km² with geographic coordinates at Mebali 03° 13'58" South Latitude and 119°49'42" East Longitude with temperatures ranging from 16-30ºC. Gandang Batu Sillanan District has an altitude of 980 m above sea level. The area of Benteng Ambeso and Gandang Batu Village is 6.57 km^2 and 12.92 km^2, respectively.

2.2. Tools and materials

The tools used are a set of PCs (personal computers), Microsoft Office, SPSS software, cameras, and writing instruments. The materials used were 7 years of Meteorological Station climate data (2012 to 2018 period including monthly humidity data, monthly temperature data, and monthly rainfall data), questionnaires, and data on the Coffee Berry Borer (CBB) pest attack from 2014 to 2017.

2.3 Research stages

This research is in the form of a survey (literature study, field observation, and interviews). The determination of the research location was carried out purposively based on the consideration that the location was in Tana Toraja Regency, which is one of the centers of coffee development. The data used in this study consisted of primary data and secondary data.

2.4. Types of data and data sources.

The data used in this study consisted of primary data and secondary data. Primary data were obtained through field surveys in the study area, filling out 30 coffee farmers' questionnaires (questionnaire) and in-depth interviews with communities / coffee farmers in Gandang Batu Sillanan District, Benteng Ambeso Village and Gandang Batu Village and related parties.

Secondary data consist of 2012-2018 climate data (monthly temperature data, humidity data and rainfall data) which were obtained from the Class 1 Maros Climatology station. The CBB pest attack area data were obtained from the Plantation Seed Quality Certification Center (BSMBP).

The data on the area of pest attacks obtained is monthly data so that the climate data is adjusted to the area data of the pest attack. The attack area data is the area of the affected plants expressed in hectares. The intensity of pest attack is quantitatively expressed in percent (table 1).

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Table 1. Pest attack intensity level [16].

Category	Level of attack
<25 %	Light
25 – 50 %	Medium
50-90 %	Severe
>90 %	*Puso**

*Puso is attributesd to the condition of hollow grain.

2.5. Data collection methods.
In this study, the data collection methods were carried out as follows:

2.5.1. Survey method. This technique is used to collect data or information about the population. The survey method is a research method that uses a questionnaire as the main instrument for collecting data.

2.5.2. Questionnaire. This technique is done by providing a list of questions to the respondent to answer. Respondents were selected by purposive sampling technique based on respondents who have a close relationship with the object of research. The contents of the questionnaire were in the form of respondent's identity, profile of coffee planting conditions, aspects of cultivation, pest attacks on farmers' coffee plants, and pest control.

2.5.3. Observation. Observations were made directly in the field where the respondent was. In this case the research observes how the conditions of smallholder plantations, cultivation techniques performed by farmers, pests that attack coffee plants, how to control pests and how the farmers' coffee production results. This was done to find in-depth information about the condition of the people's coffee plantations and to cross check the conditions.

2.5.4. Literature study. Done by collecting information from existing references or knowledge by studying or reading literature related to the subject of research.

2.5.5. Documentation. Important documentation as supporting data obtained through relevant agencies as a complement to research.

2.6. Data processing and analysis
The analysis used to determine the effect of climate on pest attacks is multiple regression. Climatic factor data is used as the dependent variable and the CBB attack area data as the independent variable. The extensive data on CBB pest attacks and climate data were input into Microsoft Excel and then entered into the SPSS application. The data were analyzed using multiple linear analysis and simultaneous significance testing (F-test) and individual parameter significance testing (T statistical test). Multiple linear SPSS output in the form of ANOVA, coefficient and correlation tables. Multiple linear regression analysis was carried out to obtain the relationship of five climatic factors, namely maximum temperature, minimum temperature, average temperature, humidity, overall rainfall to the level of attack, so that the relationship between climatic factors and the extent of CBB attack in general can be known. The multiple linear regression equation is as follows:

$$Y=a + b1x1 + b2x2 + b3x3 + b4x4 + b5x5$$

Where:
Y = area of CBB attack
x1 = Maximum Temperature

x2 = Minimum Temperature
x3 = Average Temperature
x4 = Moisture Data
x5 = Rainfall Data
a, b = constant

(The degree of closeness of the relationship between Y and X is expressed in terms of the coefficient of determination (R^2), whose values range from 0-100%).

3. Results

3.1. Study sites

This research was conducted in Gandang Batu Sillanan District, Benteng Ambeso Village and Gandang Batu District, Tana Toraja Regency. Gandang Batu Sillanan District is geographically located between -3º13'20 "South latitude, 119º50'5" with temperatures ranging from 16-30ºC and altitude 980 meters above sea level. The northern boundary is North Toraja Regency and West Sulawesi Province, to the south is Enrekang Regency and Pinrang Regency, to the east is Luwu Regency, and to the west is West Sulawesi Province. The area of Benteng Ambeso Village is 6.57 km^2 and Gandang Batu Village is 12.92 km^2. Tana Toraja Regency has an area of 2,054.30 square kilometers with an elevation of 400-3,075 masl which includes 19 sub-districts, 47 sub-districts and 112 Lembang. Tana Toraja Regency includes a wet tropical climate, the average temperature ranges from 15-28ºC with humidity between 82–86%, average rainfall 1500 mm / year [17].

Tana Toraja Regency is one of the areas in the administrative area of South Sulawesi Province which is located about 331.3 km from the city of Makassar or geographically located between 2º44'21,296 "-3º23'23,505 " South Latitude 119º22'14,322 " - 120º2 ' 37,566 "East Longitude. The altitude varies between 1,300-1,700 masl. Tana Toraja Regency has an area of 2,054.30 km^2. The total population of Tana Toraja Regency is 231,519 people consisting of 117,030 male and 114,489 female residents [18].

Most of the topography of Tana Toraja Regency is relatively wavy and hilly, while the flat topography is relatively small. Areas that have a flat slope (0-8%) are generally located in the eastern area and along the main road. Furthermore, areas that have a land slope of 8-15% are scattered throughout the Tana Toraja Regency area, while land slopes above 40% are generally located in the west of Tana Toraja Regency such as Simbuang District, Bonggakaradeng District, Masanda District and several other sub-districts. Tana Toraja Regency is one of the areas in South Sulawesi that has the potential for the development of Arabica coffee because of its large planted area, the environment and agro-climatology are very supportive.

In Indonesia, it is estimated that more than 20% of the attacks are on smallholder coffee plantations, which cover an area of about 90% or 1,250,000 hectares with a total coffee production of 676,476 tons from 1,295,000 hectares. Wiryadiputra [19], assumes that the yield loss due to CBB pests is more than 10% per year or 50 kg / ha. The area for planting Arabica coffee plantations is 1,520 with a total production of 567 tons and Robusta coffee covering an area of 216 with a total production of 62.64 tons [20]. The average coffee production in Gandang Batu Sillanan District, Tana Toraja Regency is still low. This is thought to be due to the fact that plant maintenance has not been as recommended. The low coffee production of farmers is due to, among other things, the garden is poorly maintained or maintained and has become a hotbed of pests and plant diseases.

3.2. Climatic conditions and CBB pest attack

Based on the data obtained, the relationship between the weather elements namely average temperature, air humidity, and rainfall, in a span of 7 years, and the area of pest attack are shown in figure 1, figure 2 , and figure 3, respectively.

3.2.1. Average temperature. In general, the average temperature, maximum temperature, and minimum temperature in Tana Toraja Regency follow the same pattern (figure 1). The monthly average temperature ranges from 21.67-23.07 ºC. The maximum monthly temperature ranges from 22.2-23.6

°C. The monthly minimum temperature ranges from 21.2-22.6 ºC. The highest temperature peak occurs in November and the lowest in July. At the time of entering the rainy season the temperature tends to decrease, namely in the months of November to July. The decrease is caused by the lack of intensity of sunlight due to more frequent rains. The average temperature is very volatile in 2016. The high temperature increase occurs from August to the maximum in November. This is possible due to the influence of El-Nino in 2016 which resulted in an increase in temperature. El-Nino events are usually associated with long drought or drought events because the decrease in rainfall is far from normal, especially in the dry season [21]. This increase in temperature was also followed by a reduction in rainfall, causing drought in several regions of Indonesia. This incident has an impact on decreasing coffee yields in certain regions. The lowest average temperature occurred in June 2012. The highest average temperature occurred in 2016, namely 22.82 ºC.

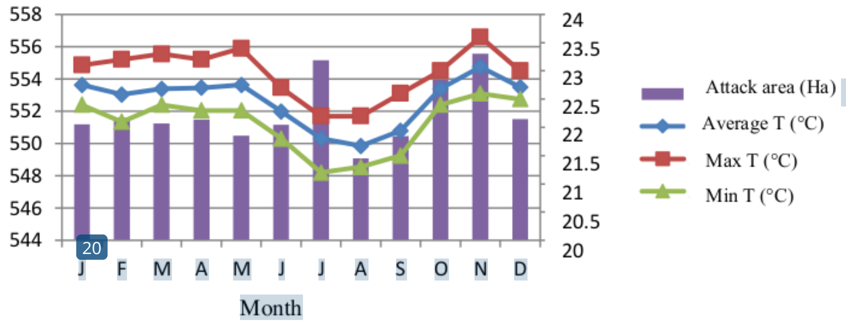

Figure 1. Relationship between monthly average temperature and the area of pest attack.

Based on figure 1 above, the area of monthly CBB pest attacks for the 2014-2017 period has increased rapidly in July and November. The lowest average air temperature occurs in August. The number of attacks began to increase until November.

The maximum temperature is the highest temperature measured in the observation area. The effects of air temperature on plant pests include controlling the development, survival and spread of insects. The monthly maximum temperature has decreased in the period May-August. This is influenced by environmental conditions that are humid due to the rainy season. The largest attack area occurred in November, with a total attack area of 555 ha at a maximum temperature of 23.6 °C.

Minimum temperature is the lowest temperature measured in a certain period of time. Temperature that is too low causes disruption to the growth and development of pests. This can be seen in figure 1. Minimum temperatures in July, August and September. In November there was a widespread explosion of pest infestation with a minimum temperature of 22.6 °C. In the following month the CBB population decreased due to a decrease in temperature so that the area of the attack became 551.5 ha.

Insect activity will be faster and more efficient at high temperatures, but it will reduce the insect's life span. In some insects high temperatures will inhibit metabolism or result in death. The high and low intensity of sunlight is directly proportional to the high and low temperature of the air.

3.2.2. Humidity. Humidity indicates the moisture content in the air. Air humidity in Indonesia is always high, which is above 60%. Tana Toraja air humidity ranges from 77-86% (figure 2). The figure above represents the relationship between the mean humidity over a period of 7 years. The Tana Toraja region experienced a decrease in humidity from July-October and an increase in November-December. During the rainy season the moisture content in the air is greater so that the value of air humidity increases from January to June and then decreases and increases in November to December. The highest humidity occurs in 2016. Humidity is influenced by rainfall and wind. The higher the rainfall, the higher the humidity because air humidity shows the condition of water vapour in the air.

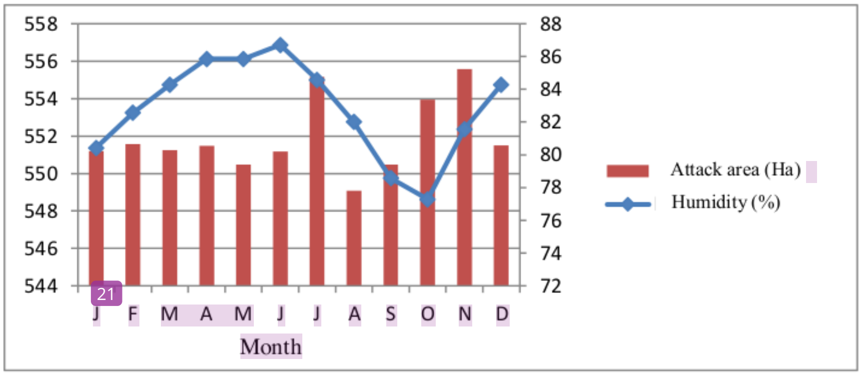

Figure 2. Relationship between monthly average air humidity and the area of pest attack.

The relationship between humidity and pest infestat*ion* area can be interpreted by figure *2*. Humidity in the air can increase insect fecundity and fertility. The highest air humidity occurs in June with an area of CBB pest attack, namely 551 ha. The lowest air humidity occurs in October with a value of 77% with an attack area of 553 ha. The optimum humidity for the development of CBB ranges from 90% -95%.

3.2.3. Rainfall. The rainfall climate element in the Tana Toraja region is a transitional area that does not clearly indicate the rainy season and dry season. The area of CBB pest attack in the Tana Toraja area in the 2012-2017 period varied (figure 3). The increase in attack area is inversely proportional to the increase in the CBB pest population itself in the study area. The following is an analysis of the relationship between air temperature and the area of attack.

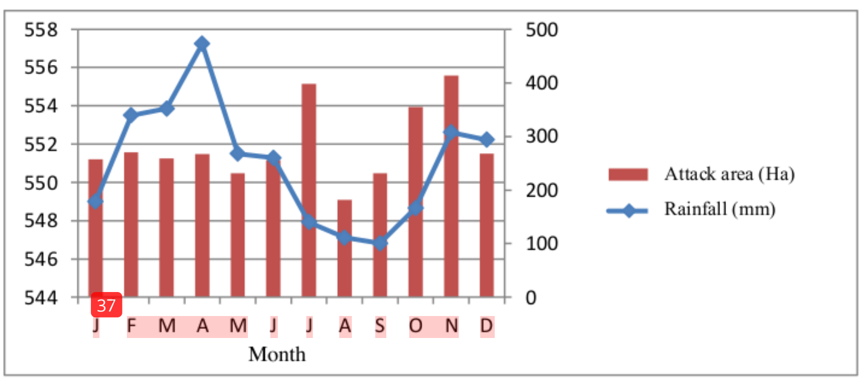

Figure 3. Relationship between monthly average rainfall and the area of pest attack.

The lowest rainfall occurs in September, namely 100 mm with an attack area of 550 ha. The highest rainfall occurs in April, namely 472 mm with an attack area of 551 ha (figure 3). From April to October, the rainfall in Tana Toraja Regency is classified as low, while the area of pest infestation increases drastically in July, October and November. It is suspected that at that time the availability of food was very abundant because the coffee plants began to bear fruit. From the results of a survey conducted in the research area, CBB insects will attack coffee plants more during the dry season than during the rainy season. During the rainy season, coffee plants will be attacked more than by pests. Coffee production centers that have experienced an increase in temperature and rainfall are advised to replace coffee plants with tolerant varieties.

The population explosion of a pest may be closely related to the periodicity of the rain distribution. Seasonal variations in rainfall affect species abundance. When rainfall is low, some insect species are high in abundance, although host availability is low. High rainfall can result in direct mortality of insects, or allow the development of insect pathogens [22].

3.3. *Area of pest attack*

Data from observations and interviews with respondent farmers indicate that the types of pests that attack coffee plants are CBB, fruit rot, wild boar and rats. However, the dominant pest that attacks coffee plants is CBB (table 2).

Table 2. Area of CBB pest attack (2014-2017) in Tana Toraja Regency, Gandang Batu Sillanan District [19].

Month	2014	2015	2016	2017	Average
J	551.10	551.65	551.45	550.60	551.20
F	550.95	551.70	551.20	552.50	551.59
M	550.90	551.80	550.80	551.50	551.25
A	551.00	551.82	552.35	550.77	551.48
M	550.95	551.75	551.45	547.80	550.48
J	550.90	551.73	550.35	551.73	551.17
J	550.95	551.50	550.67	567.51	555.15
A	551.05	551.40	542.52	551.40	549.09
S	551.15	551.65	547.44	551.65	550.47
O	551.03	551.75	551.45	561.55	553.94
N	550.70	551.90	570.83	548.88	555.57
D	551.10	552.00	530.82	572.10	551.50
Average	550.98	551.72	550.11	554.83	551.91

Secondary data, 2019.

Improper implementation of coffee plant maintenance causes crop production to be less than optimal and susceptible to pests and diseases. In the concept of Integrated Pest Control (IPM) pesticides are one of the control components that must be in line with the components of biological control that are efficient in controlling certain pests and diseases and are easily biodegradable because pesticide use does not require a large amount of time, cost and energy and plays a major role in saving yields.

The pests that attack coffee plants will be controlled physically and use saprotan traps. Farmers in Gandang Batu Sillanan District rarely use chemical pest control because CBB pests damage the inside of the coffee (beans) so that it will be difficult to control. The chemicals that are sprayed on the coffee plants will not only control the CPB pests, they will actually pollute the environment and disturb the health of farmers.

3.4. *Multiple regression analysis*

The results of a complete multiple linear regression analysis using SPSS Software to see the influence of climatic factors on CPB pests on coffee plants can be seen in table 2 with a summary and description as in the following table 3.

Table 3. Results of multiple regression analysis.

Model	Regression coefficient	Probability	Significance
Area of pest attack	544.292	0.000	
Maximum Temperature	-7.321	0.121	No significant effect on area of pest attack
Minimum Temperature	-15.960	0.041	Had significant effect on area of pest attack
Average Temperature	24.739	0.027	Had significant effect on area of pest attack
Humidity	-356	0.221	No significant effect on area of pest attack
Rainfall	0.005	0.581	No significant effect on area of pest attack

Primary data processed, 2019.

The results of a complete multiple linear regression analysis using SPSS Software to see the influence of climatic factors on CPB pest attacks on coffee plants can be seen in table 3 with a summary and elaboration. The multiple linear regression equation between maximum temperature (X1), minimum temperature (X2), average temperature (X3), humidity (X4), rainfall (X5) to the area of CPB pest attack (Y) obtained the following equation:

Y = 544.292 - 7.321X1 – 15,960X2 + 24.739X3 - 356X4 + 0.005X5

The multiple linear regression equation above means:

1. The value of 544.292 is the value of the area of pest attack if the five independent variables are considered constant.
2. The value of - 7.321 indicates that the value of the area of attack will decrease by 7.321% if there is an increase of 1 ° C at the maximum temperature.
3. Value - 15,960 indicates the attack area value will decrease by 15,960% if there is an increase of 1 ° C at the minimum temperature.
4. The value of 24.739 shows that the value of the area of attack increases by 24.739% if there is an increase of 1 ° C in the average temperature.
5. Value - 356 indicates the value of the attack area decreases by 356% if there is a 1% increase in the humidity value.
6. The value of 0.005 indicates that the value of the area of attack increases by 0.005% if there is an increase of 1 mm in the value of rainfall.

From these results, only the average temperature and minimum temperature factors have a significant effect on the area of CBB pest attack.

3.5. *Coefficient of determination (R^2)*

The coefficient of determination (R^2) is useful for measuring how far the model is able to explain the variation in the independent variable. The value of the coefficient of determination ranges from 0 to 1. The small value of R^2 (close to 0) means that the ability of the independent variable is very limited, and close to one means that the independent variable provides almost all the information needed to predict the dependent variable.

Based on the results of calculations using multiple linear regression analysis, the coefficient of determination (table 4) obtained is the R square value of 0.609, meaning that 60.90% of the area of CBB pests in coffee plants can be explained by climatic factors, while the remaining 30.10% is explained by climatic factors other variables outside the variables used.

Table 4. Coefficient of Determination (R^2) the effect of maximum temperature, minimum temperature, average temperature and rainfall on the area of CBB pest attack.

					Change Statistics				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	.780[a]	.609	.283	1.65675	.609	1.867	5	6	.234

a. Predictors: (Constant), Maximum temperature, minimum temperature, average temperature, humidity, and rainfall.

3.6. Simultaneous significance testing (f Test)

Simultaneous test with the F-test aims to determine the joint effect of the dependent variable on the independent variable.

Simultaneous test with the F-test aims to determine the joint effect of the dependent variable on the independent variable. Testing the effect of all independent variables in the model can be done with the F test. The F test basically shows whether all the independent variables included in the model have an overall effect on the dependent variable as presented in table 5. The test results of multiple linear regression analysis (table 5) show the calculated F value of 1.867 with a p-value of 0.234> a significant level of 0.05 which indicates not significant.

Table 5. F-test results the effect of maximum temperature, minimum temperature, averafe temperature and rainfall on the area of CBB pest attack.

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	25.622	5	5.124	1.867	.234b
Residual	16.469	6	2.745		
Total	42.091	11			

b. Predictors: (Constant), Maximum temperature, minimum temperature, average temperature, humidity, and rainfall.

a. Dependent Variable: area of pest attack.

3.7. Significant testing of individual parameters (T Statistical Test)

Partial test with T-test was conducted to determine the influence of each climate factor on the level of CBB pest attack on coffee plants in Tana Toraja Regency partially on coffee productivity is presented in table 6.

The results of the T-test on multiple linear regression analysis show the p-value for each of the climatic factors, if the p value <0.05 significance level means that the influence of the independent variables has a significant effect. The T-test that was carried out produced the following answers:

1. The maximum temperature variable has a probability value of 0.121> 0.05 which means it is not significant. In conclusion, the maximum temperature partially rejected does not have a significant effect on the level of CPBP pest attack.
2. The minimum temperature variable has a probability value of 0.041 <0.05, which means that it is significant. In conclusion, the partially accepted minimum temperature has a significant effect on the level of CPBP pest attack on coffee plants.

3. The average temperature variable has a probability value of 0.027 <0.05, which means that it is significant. In conclusion, the average temperature accepted partially has a significant effect on the level of CPBP pest attack on coffee plants.
4. The humidity variable has a probability value of 0.221> 0.05 which means it is not significant. The conclusion is that partially rejected moisture does not have a significant effect on the level of CPBP pest attack on coffee plants.

The rainfall variable has a probability value of 0.581> 0.05 which means it is not significant. In conclusion, the partially rejected rainfall does not have a significant effect on the level of CBB pest attack on coffee plants.

Table 6. T-test results the effect of maximum temperature, minimum temperature, average temperature and rainfall on the area of CBB pest attack.

Model	Unstandardized Coefficients B	Standard Errors	Standardized Coefficients Beta
Area of attack	544.292	53.551	
Maximum Temperature	-7.321	4.056	-1.677
Minimum Temperature	-15.960	6.155	-4.002
Average Temperature	24.739	8.519	5.623
Humidity	-.356	.260	-.542
Rainfall	.005	.009	.302

b. Dependent Variable: Area of pest attack.

4. Discussion

The results above indicate that there are several climatic factors that affect the level of CBB pest attack in Tana Toraja Regency, namely the minimum temperature and the average temperature. The minimum temperature with a probability value of 0.041 <0.05 means that it has a significant effect on the level of CBB pest attack in Tana Toraja Regency, Gandang Batu Sillanan district. The average temperature with a probability value of 0.027 <0.05 has a significant effect on the level of CBB pest attack. While the factors of maximum temperature, humidity and rainfall did not have a significant effect on the area of CBB pest attack.

There are several factors that cause maximum temperature, humidity and rainfall to not have a significant effect on CBB pest attacks, namely the factor of providing shade, the presence of secondary pest explosions, technical culture and methods of controlling CBB pests. Some of the shade used on coffee plants is old and is no longer effective as a shade. The distance between the coffee plant and the shade is too tight, so the climate around the plantation becomes humid. Humid conditions are one of the important factors for the development of CBB pests. This is in accordance with the opinion of Susilo [5] that planting coffee with tight shade, 5 times more fruit infected with CPB and the development of H. is almost faster than plants without or less shade. Likewise, the planting that is fertilized throughout the year will support sustainable CBB breeding. Apart from environmental factors, the cultivation method also affects the level of CBB attack.

Another factor that influences the maximum temperature, humidity and rainfall that does not have a significant effect on pest attack is the presence of a secondary pest explosion. The use of pesticides that are intended to control certain types of pests, can even lead to the emergence of other types of pests. Because pests are constantly under pressure from pesticides or other chemicals, through natural processes, pest species are able to form new strains that are more resistant to pesticides.

Secondary pest outbreaks in coffee crops can occur some time after pesticide application, or at the end of the growing season or the following growing season. Secondary pest outbreaks can be more destructive than previous target pests or major pests [23].

Observations in the field show that heavy rain often occurs in the afternoon. Rain can sweep away the CBB beetles that are outside the fruit so that it can reduce the CBB pest population. In addition, the condition of the land at the time of the observation was relatively clean of weeds, but the skin of the coffee pods would be piled around the coffee plant. The CBB beetle will be able to live on the rest of the coffee cherries that fall to the ground. If the surface of the soil is clean from fruit debris, the beetle's life cycle can also be interrupted. This is in accordance with the opinion of Damon [24] that a good technical culture is able to suppress the development of CBB.

Climate has a direct effect on birth and death rates, indirectly, climate affects the abundance of insects. This is in accordance with the opinion of Ysvina [22] that the emergence of pests occurs at a maximum humidity of 90% with a temperature of 20-25 °C. At 90-100% humidity there is a significant increase. However, if the humidity is 90-100% but the air temperature is below 20 ° C, the pest occurrence will be low and even die at 15 °C. Temperatures above 25 °C do not lead to an increase in the pest population. The results of the field survey showed that the CBB attack was still relatively mild (25%). This CBB attack is still within normal limits and has not caused significant loss of yields for farmers.

Conclusion

Based on the results of research that has been conducted on the influence of climatic factors on CBB coffee pest attacks in Tana Toraja Regency, it can be concluded that:

- There are climatic factors that can significantly influence the level of CBB pest attack in Tana Toraja District, Gandang Batu Sillanan District is the minimum temperature (probability value 0.041 <0.05) and the average temperature (probability value 0.027 <0.05). While the maximum temperature (probability value 0.121> 0.05), humidity (probability value 0.221> 0.05) and rainfall (probability value 0.581> 0.05) do not have a significant effect on the area of pest attack because the probability value is greater than 0.05.
- Based on the results of calculations using multiple linear regression analysis, the coefficient of determination obtained is an R square value of 0.609, meaning that 69.90% of the area of CBB pest attack of coffee plants can be explained by climatic factors, while the remaining 30.10% is explained by other variables outside the variables used.

Reference

[1] Mawardi S 2009 Establishment of geographical indication protection system in Indonesia, case in coffee *Proc. Worldwide Symposium on Geographical Indications*, jointly organized by the World Intellectual Property Organization (WIPO) and the Patent Office of the Republic of Bulgaria, Sofia, June 10 to 12, 2009

[2] Sudjarmoko B 2013 *Peluang dan Tantangan Pasar Kopi Indonesia di Pasar Domestik dan Pasar Internasional. Media Komunikasi Tanaman Industri dan Penyegar* (Bogor: Pusat Penelitian dan Pengembangan Perkebunan) Vol 2

[3] Badan Pusat Statistik Kabupaten Tana Toraja 2018 *Data tentang iklim dan Curah Hujan* (Tana Toraja: Agromedia Pustaka)

[4] Ditjenbun (Direktorat Jenderal Perkebunan) 2016 *Statistik perkebunan Indonesia Komoditas kopi 2015-2017* (Jakarta: Ditjenbun RI) 83 p

[5] Susilo A W 2008 *Ketahanan Tanaman Kopi (Coffea spp.) Terhadap Hama Penggerek Buah Kopi (Hypothenemus hampei Ferr.)* (Jember: Pusat Penelitian Kopi dan Kakao)

[6] Ridwan I, Ala A, Irfansyah T, Rafiuddin, Farid BDR M and Haring F 2020 Good Agriculture Practice (GAP) of arabica coffee (Coffea arabica L.): Implementation on the smallholder estate in Enrekang Regency *IOP Conf. Series: Earth and Environment. Sci.* **575** 012113

[7] [Ditjenbun] Direktorat Jenderal Perkebunan 2014 *Statistik Pekebunan Indonesia Komoditas Kopi 2013-2014* (Jakarta (ID) : Direktorat Jenderal Perkebunan)

[8] Eva N 2017 *Pengembangan Sistem Informasi Iklim Berbasis Pemodelan Dinamika Populasi Untuk Rencana Pengendalian Penggerek Batang Padi Kuning* (Bogor: Pasca Sarjana IPB) 67 p

[9] Brown M E and Funk C C 2008 Food security under climate change *Science* **319** 580–581

[10] Hannah L, Roehrdanz P R, Ikegami M, Shepard A V, Shaw M R, Tabor G, Zhi L, Marquet P A and Hijmans R J 2013 Climate change, wine, and conservation *Proc Natl Acad Sci*
[11] Solomon S, Qin D and Manning M 2007 *Climate Change 2007: The Physical Science Basis. Contribution of Working Group Ifor the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (UK: Cambridge University Press)
[12] Musa Y, Bahrun A H and Rini A 2020 Farmers understanding and practices on shading and pruning for Arabica coffee – a survey and analysis on the effects to the yields *IOP Conf. Series: Earth and Environment. Sci.* **575** 012158
[13] Cerri C E P, Sparovek G, Bernoux M, Easterling W E, Melillo J M and Cerri C C 2007 Tropical agriculture and global warming: impacts and mitigation options *Scientia Agricola* **64** 83–99
[14] Durham S 2004 Stopping the coffee berry borer from boring into profits *Agric. Research* **52** 10-11
[15] Erdiansyah N P and Yusianto 2012 Hubungan intensitas cahaya di kebun dengan profil cita rasa dan kadar kafein beberapa klon kopi Arabika *Pelita Perkebunan* **28**(1) 14-22
[16] [Ditjentan] Direktorat Jenderal Pertanian Tanaman Pangan 1986 *Pengendalian Hama Terpadu Wereng Coklat Pada Tanaman Padi* (Jakarta: Ditjentan RI)
[17] Badan Pusat Statistik Kabupaten Tana Toraja 2019 *Data tentang iklim dan Curah Hujan* (Tana Toraja: Agromedia Pustaka)
[18] [PPKKI] Pusat Penelitian Kopi dan Kakao Indonesia 2006 *Pedoman Teknis Budi Daya Tanaman Kopi* (Jember: Indonesia Coffee and Cacao Research Institute)
[19] Wiryadiputra S 2007 *Pengelolaan Hama Terpadu Pada Hama Penggerek Buah Kopi, Hypothenemus hampei (Ferr.) dengan Komponen Utama pada Penggunaan Perangkap Brocap Trap* (Jember: Pusat Penelitian Kopi dan Kakao Indonesia Jember) p 2-9
[20] IPCC (Intergovernmental Panel on Climate Change) 2013 Climate change 2013 *The Physical Science Basis. Contribution of Working Group I To The Fifth Assessment Report of The Intergovernmental Panel on Climate Change* (UK: Cambridge University Press)
[21] Boer R, Buono A, Sumaryanto, Surmaini E, Rakhman A, Estiningtyas W, Kartikasari K and Fitriyani 2009 Agriculture sector. *Technical Report on Vulnerability and Adaptation Assessment to Climate Change for Indonesia's Second National Communication (Jakarta:* Ministry of Environment and United Nations Development Programme)
[22] Ysvina 2010 Hubungan Cuaca dan Hama
[23] Retno A 2006 Usaha pengendalian pencemaran lingkungan akibat penggunaan pestisida pertanian *Jurnal Kesehatan Lingkungan* **3** (1) 95-106
[24] Damon A 2000 A Review of the biology and control of the coffee berry borer Hypothenemus hampei (*Coleoptera: Scolytidae*) *Bulletin of Entomological Research* **90** 453-465

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