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Modeling the effect of climate on na-oogst tobacco production in Jember

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Abstract. Tobacco (*Nicotiana tabacum* L.) makes a significant contribution to the source of farmers' income and the provision of employment opportunities. Tobacco plants are very susceptible to being influenced by the climatology and geography of the region. Na-Oogst tobacco is specifically cultivated in East Java in the Besuki Ex-Karesiden area which includes Jember and Bondowoso regencies, its mainly used for making cigars outside (dekblad), cigar dressings (omblad), and filling cigars (filler). Tobacco plants are sensitive to environmental factors including climatic factors, such as rainfall, humidity, and temperature. The climatic conditions of rainfall, both the amount and the distribution are very diverse so that it affects the growth, production, and quality of tobacco. Based on this, this study aims to identify characteristics, analyze and determine the modeling of the influence of climate factors on tobacco productions in Jember Regency. This is very important to do to determine recommendations and policies to increase tobacco productivity. The mathematical model of the analysis on Na-Oogst tobacco production in Jember Regency is $Y = -362629 + 0.1285 \text{ rainfall} + 2.93 \text{ rainy days} + 16630 \text{ temperature} - 1377 \text{ humidity}$ with the coefficient of determination is 76.33%.

1. Introduction

Tobacco (*Nicotiana tabacum* L.) is one of the plantation crop commodities that has an important role in Indonesia. Based on statistical data, tobacco exports tend to increase, while tobacco imports have decreased. This has a positive impact on the government and tobacco farmers to increase productivity and quality so that they can compete with foreign producers [1]. Tobacco plants are very susceptible to being influenced by certain areas, such as requiring regional conditions that are climatologically and geographically suitable for the type of tobacco [2].

In 2018, the largest tobacco producers in Indonesia according to the size of their cultivation area were the Provinces of East Java, West Nusa Tenggara, Central Java, West Java with a total contribution of 94.76% to Indonesia's total tobacco production, while the largest contribution was East Java Province [3]. Tobacco cultivation and its industry are commodities that are very influential in the economy, not only for East Java but also for global economic activities [4].

Tobacco has several varieties including Voor-Oogst tobacco which is used for making white cigarettes as well as clove cigarettes and Na-Oogst tobacco, which is the type of tobacco used for the basic ingredients of making cigars and cigarillos, in addition to smoking or chewing tobacco. Besuki Na-Oogst Tobacco is mainly used for making cigars outside (dekblad), cigar dressings (omblad), and filling cigars (filler) [5]. Voor-Oogst tobacco is tobacco with a planting period at the end of the rainy season and a picking period in the dry season. Meanwhile, Na-Oogst tobacco is tobacco with a planting period at the end of the dry season and a picking period at the beginning of the rainy season [6]. Na-Oogst



tobacco is specifically cultivated in East Java in the Besuki Ex-Karesiden area which includes Jember and Bondowoso regencies, therefore this tobacco is more often known as Besuki Na-Oogst tobacco [7].

Production of tobacco plants with the Besuki Na-Oogst tobacco type in Jember Regency has decreased due to uncertain weather, high rainfall, volcanic ash from Mount Raung, and the lack of production facilities [8]. One of the main problems in the production Na-Oogst tobacco is uncontrolled weather and the production environment [9]. Tobacco plants are plants that are sensitive to environmental factors including climatic factors, such as rainfall, humidity, and temperature. The optimal temperature for tobacco plant growth is 27°C or ranges from 22-33°C [10]. While the optimal humidity for plant growth ranges from 70%-80% [6]. The climatic conditions of rainfall, both in number and distribution, are very diverse so that it affects the growth, production, and quality of tobacco [11]. Meanwhile, the optimal temperature for the growth of Besuki Na-Oogst tobacco is between 24 – 27°C with an average relative humidity of 75 – 80%. Meanwhile, moderate rainfall of about 300 mm during the growing season has the best effect on plant growth so that it can produce maximum production [11].

Based on the previous description, this study aims to identify characteristics, analyze and determine the modeling of the influence of climate factors on Na-Oogst tobacco production in Jember Regency. This is very important to do to determine recommendations and policies for increasing tobacco production in Jember Regency, both produced by farmers and by companies.

2. Method

The method of analysis in this study uses descriptive analysis and multiple linear regression analysis [12].

1. Data Source

The source of data used in this study is secondary data taken from the database of the Central Bureau of Statistics of Jember Regency including data of uncontrolled weather [9] that is rainfall, rainy days, temperature, humidity, and tobacco production from 2007 to 2020 [13].

2. Operational Definition and Research Variables

The variables used in this study are divided into two, namely the independent variable and the dependent variable. The independent variables consist of rainfall, rainy days, humidity, and air temperature. While the dependent variable is tobacco production (quintal).

3. Construct Model

Multiple linear regression is a regression equation that describes the relationship between more than one independent variable (X) and one dependent variable (Y) [11]. The hypothesis that must be tested in multiple linear regression analysis is

$$H_0 : \beta_1 = \beta_2 = \dots = \beta_{p-1} = 0$$

$$H_1 : \text{Not all } \beta_k \text{ (} k=1,2,\dots,p-1 \text{) equal to zero}$$

If x_1, x_2, \dots, x_p is predictor variables as p that have a relationship with a response variable Y , then in general a linear regression model with one response variable is

$$Y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \dots + \beta_p x_p + \varepsilon$$

With an error condition has the following characteristics:

- ✓ $E(\varepsilon_j) = 0$;
- ✓ $Var(\varepsilon_j) = \sigma^2$ (constant);
- ✓ $Cov(\varepsilon_j, \varepsilon_k) = 0$; and
- ✓ $\varepsilon \sim n(0, \sigma^2)$, for $j \neq k$

If presented in matrix notation, the formula above becomes

$$\begin{bmatrix} Y_1 \\ Y_2 \\ \vdots \\ Y_n \end{bmatrix} = \begin{bmatrix} 1 & x_{11} & x_{12} & \cdots & x_{1p} \\ 1 & x_{21} & x_{22} & \cdots & x_{2p} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ 1 & x_{n1} & x_{n2} & \cdots & x_{np} \end{bmatrix} \begin{bmatrix} \beta_0 \\ \beta_1 \\ \vdots \\ \beta_p \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \vdots \\ \varepsilon_p \end{bmatrix}$$

or $Y = \beta X + \varepsilon$

With the error condition being

- ✓ $E(\varepsilon) = \mathbf{0}$;
- ✓ $Cov(\varepsilon) = E(\varepsilon\varepsilon') = \sigma^2\mathbf{I}$ [12].

The assumptions that must be met in multiple regression analysis are:

- No multicollinearity (correlation between independent variables)
- There is no heteroscedasticity (constant error variance)
- Normality (normally distributed error)
- There is no autocorrelation (the error is random)

3. Result and discussion

3.1 Production of Na-Oogst Tobacco

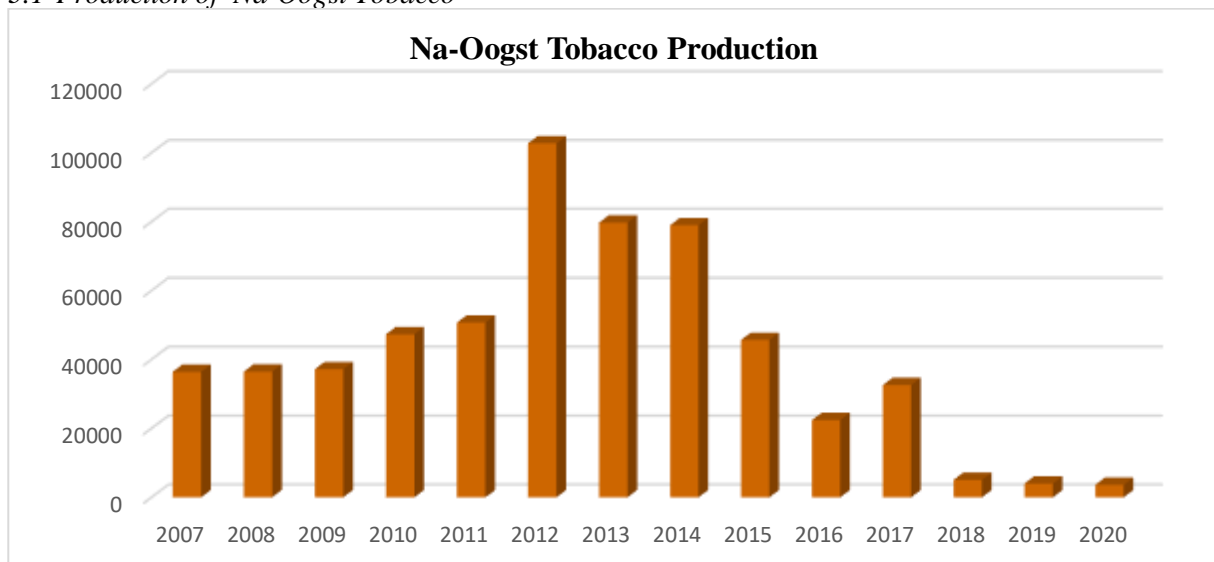


Figure 1. Production of Na-Oogst Tobacco

The results of the analysis of Na-Oogst tobacco production in Jember Regency for the last 14 years in 2007-2020 show that tobacco production during the 2007-2020 period fluctuated by having an average production Na-Oogst tobacco of 41,648.19 quintals. It can be seen in Figure 1 that the production of Na-Oogst tobacco above the highest average was in 2012 with a production of 102,770,0 and the lowest production was in 2020 with a production of 3,637.48 [5]. The development of Na-Oogst tobacco production in Jember Regency has decreased over a while, this is caused by several factors such as farmers not fully using the recommended technology in cultivation, lack of production facilities and information, limited knowledge, and limited land ownership. Besuki Na-Oogst tobacco production in Jember Regency experienced a drastic decline in the period, one of which was in 2015, this is caused by the erratic weather, the volcanic ash of Mount Raung and the lack of provision of production facilities, and the prices of some production inputs that have not been reached by farmers so that not many farmers grow the Besuki Na-Oogst commodity [8].

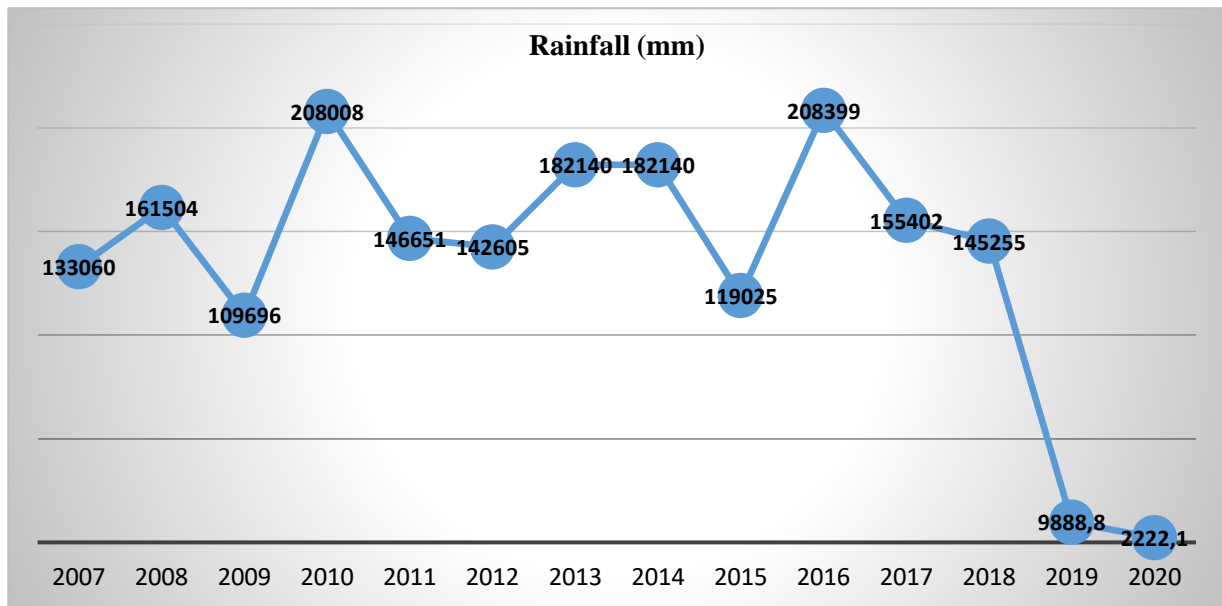


Figure 2. Rainfall

Rainfall for 14 years fluctuated with an average rainfall of 136,143 mm/year. It can be seen in Figure 2 that the highest above-average rainfall occurred in 2016 with a total rainfall of 208,339 mm/year and the lowest amount of rainfall occurred in 2020 with a total rainfall of 2222.1 mm/year. This is in line with [16] that rainfall can also be influenced by El Nino and La Nina phenomena. El Nino phenomena are climate anomalies followed by a decrease in rainfall and an increase in air temperature, while the La Nina phenomenon stimulates an increase in rainfall above normal rainfall [17]. One of the La Nina phenomena that occurred in Indonesia occurred in 2010-2011 and 2016-2017 which resulted in experiencing quite high rainfall while in 2015 and 2018-2020 there was a decrease in rainfall caused by the El Nino phenomenon [18].

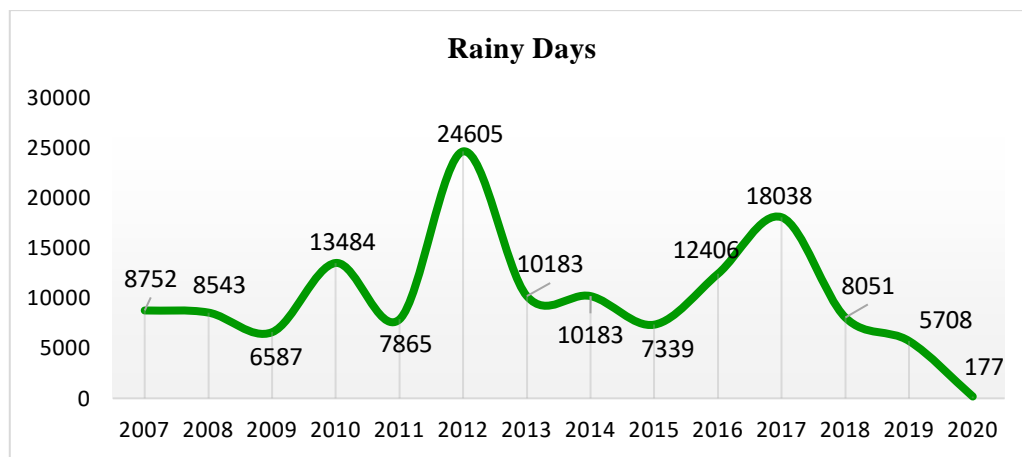


Figure 3. Rainy Days

Meanwhile, the results of the analysis of rainy days for the last 14 years in 2007-2020 show that the number of rainy days during the period 2007-2020 has fluctuated with an average rainy day of 10137.21 rainy days. It can be seen in Figure 2 that the highest number of rainy days above the average was in 2012 with 24,605 rainy days and the lowest number of rainy days was in 2020 with 177 rainy days.

Rainy days in Jember Regency in 2007-2020 fluctuated, this was related to the large number of rainy days which was also influenced by rainfall.

The impact of global climate change is a change in rainfall patterns on a local or regional scale such as a shift in the trend of daily rainfall patterns and another factor that has a close relationship to affect rainy days is solar radiation [10]. Solar radiation activity affects the heat radiation captured by the atmosphere so that solar variability is the dominant factor that causes climate change in the form of daily cycles [19].

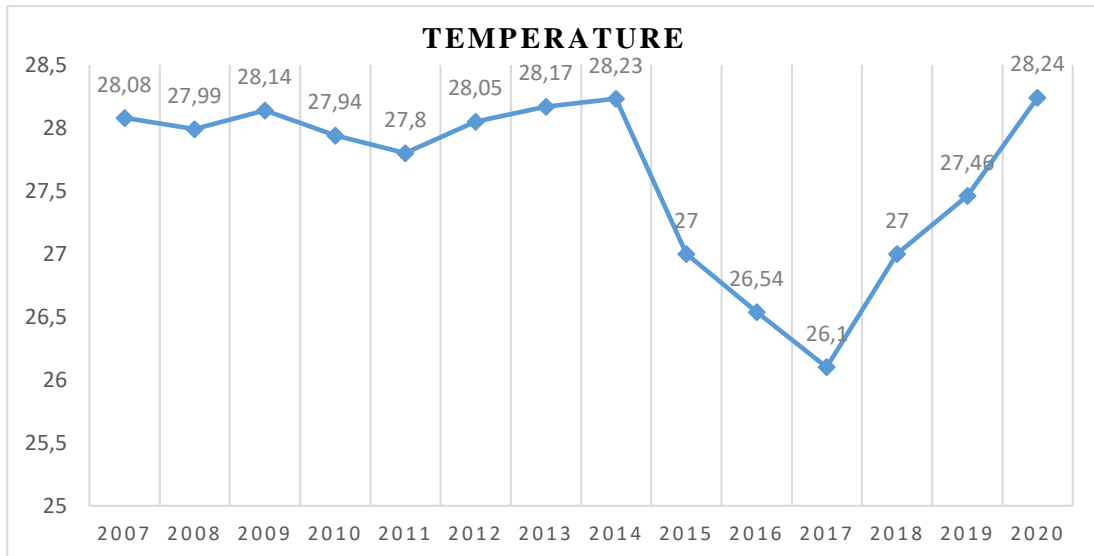


Figure 4. Temperature

Jember Regency has an average humidity of 74.28% with an average annual air temperature of 27.6 °C. In 2007 – 2014 the temperature tended to be stable then the air temperature graph decreased starting in 2015 until it reached the lowest point in 2017. The decrease in temperature was accompanied by an increase in humidity in Figure 5 then in the following year the humidity again decreased and there was an increase in the temperature graph. This shows that the higher the air temperature will be accompanied by a decrease in humidity.

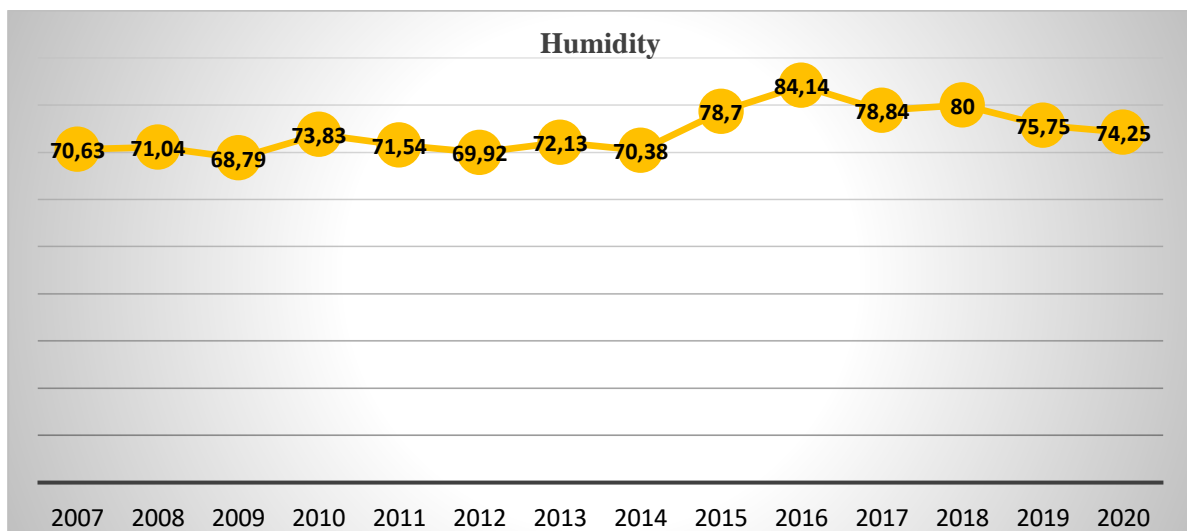


Figure 5. Humidity

3.2 Regression Modeling

3.2.1 Simultaneous Test

The hypotheses for simultaneously testing the significance of the regression parameters are:

$$H_0 : \beta_1 = \beta_2 = \dots = \beta_5 = 0$$

$$H_1 : \text{There is at least one } \beta_j \neq 0; j = 1, 2, \dots, 5$$

Rejected H_0 if $p\text{-value} < \alpha$, for $\alpha = 0.05$

Table 1. Analysis of Variance

Model	<i>df</i>	<i>Sum of square</i>	<i>Mean Square</i>	F-count	<i>P-value</i>
Regression	4	8733131893	2183282973	7,25	0,007
Residual	9	2708776757	300975195		
Total	13	11441908649			

Based on the results of the simultaneous test in Table 1, it shows that the P-value of 0.007 is less than 0.05 (α : 5%), or the F-count of 7.25 is greater than F table (3.63) so it is decided to reject H_0 , this means that all independent variables simultaneously have a significant effect on NO tobacco production in Jember Regency. So that the regression model or equation formed from this analysis is appropriate and meets the assumptions of the goodness of the regression model.

3.2.2 Partial Test

A partial test was used to determine the effect of each independent variable partially on Na-Oogst tobacco production in Jember Regency. The results of the partial test analysis are shown in table 2 as follows:

Table 2. Partial Test Result

Variable	Coefficient	SE Coefficient	T-Count	P-value	VIF
(Constant)	-362629	622081	-0,58	0,574	
Rainfall (mm)	0,1285	0,0937	1,37	0,203	1,48
Rainy Days	2,93	1,14	2,57	0,030*	1,91
Temperature	16630	16360	1,02	0,336	5,57
Humidity	-1377	2413	-0,57	0,582	5,28

It can be seen in Table 2 that there is one partially significant. This is indicated by the P-value which is less than 0.05, which is in addition when compared to the T value of the statistical table (± 2.26), the t-value is greater than the T.table on the **rainy day variable**. So it can be concluded that there is an independent variable that partially significantly influences the production of Na-Oogst tobacco in Jember Regency, namely the rainy day variable. In line with the opinion of tobacco farmers in Temanggung, the current problems faced by tobacco farmers are weather and climate factor. According to farmers, the current weather is less favorable and inhibits the growth rate of tobacco plants, and even leads to crop failure. In addition, changes in weather and climate also trigger the spread of pests and plant diseases [20].

3.2.3 Regression Models

Based on the results of the regression analysis of the coefficient of determination (R^2) amount 76,33%, This means that the contribution of the independent variables, namely rainfall, rainy days, humidity, temperature, on Na-Oogst tobacco production in Jember Regency is 76.33% and the rest is influenced by other factors. The R^2 value that is close to 100% indicates that the regression model built is correct and can represent the actual situation. The regression model that is formed from is as follows:

$$Y = -362629 + 0.1285 X_1 + 2.93 X_2 + 16630 X_3 - 1377X_4$$

Where Y is Production of Na-Oogst Tobacco (quintals); X1 is Rainfall (mm/year); X2 is Rainy days; X3 is Temperature (°C); X4 is Humidity (%)

The regression model shows that the constant or intercept is **-362,629**. This means that if all variables are constant or zero, then the production of Na-Oogst tobacco is reduced by **362,629** quintals. Then the regression coefficient on the rainfall variable (X1) is **0.1285**, which means it has a positive effect on Na-Oogst tobacco production. It can be assumed that if the rainfall (X1) increases by 1 unit, the increase in Na-Oogst tobacco production is **0.1285** quintals with the assumption that the other independent variables are constant. Then the regression coefficient on the variable number of rainy days (X2) is **2.93** which means it has a positive effect on Na-Oogst tobacco production. It can be assumed that if the number of rainy days (X2) increases by 1 unit, then tobacco production increases by **2.93** quintals with the assumption that the other independent variables are constant. While the regression coefficient on the temperature variable (X3) is **16,630** which means it has a positive effect on the production of Na-Oogst tobacco. It can be assumed that if the temperature (X3) increases by 1%, there will be an increase in tobacco production of **16,630** quintals with the assumption that the other independent variables are constant. The regression coefficient for the air humidity variable (X4) is **-1377**, which means it negative effect on NO tobacco production. It can be assumed that if the air temperature (X4) increases by 1°C, there will be a decrease in tobacco production of **1377** quintals with the assumption that the other independent variables are constant.

Although the regression equation has been formed, it must meet the classical assumptions in regression. The following are the results of the examination and testing of assumptions on the formed regression model [21].

1) Normality Test

The normality test was conducted to determine the residuals obtained from the difference between Y estimates and Y original data following a normal distribution. Test the normality of the data using the Kolmogorov Smirnov test with the following hypothesis testing:

H0: Data is normally distributed

H1: Data is not normally distributed

Level significant: 5 % (0,05)

The results of the normality test show the following results

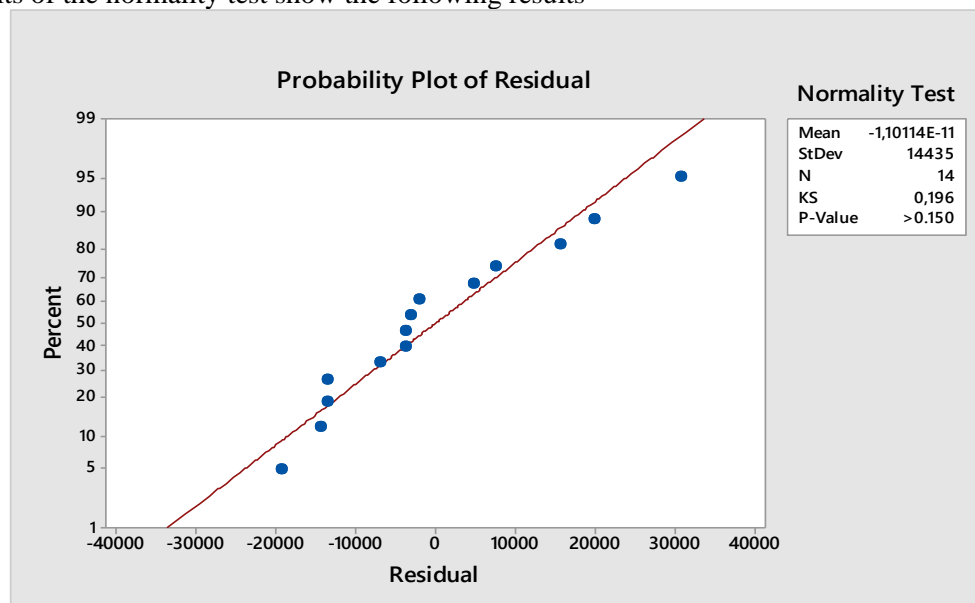


Figure 6. Normality Test

The results of the normality test can be seen from the magnitude of the p-value which is more than 0.05 and visually it can be seen that the residual points follow the normality line. This shows that the residuals meet the assumption of a normal distribution [22].

2) Multicollinearity Test

The second assumption that must be met is that there is no multicollinearity between the independent variables. One way to detect multicollinearity is by looking at the Variance Inflation Factor (VIF) if the VIF value > 10 indicates the presence of multicollinearity. Based on Table 2, it is known that the VIF value in all independent variables is < 10, so it can be concluded that there is no multicollinearity between independent variables in the regression model.

3) Autocorrelation Test

The third assumption that must be met is that there is no autocorrelation between residuals, or there is no relationship or influence from the first residual data to the next data residual. One of the ways to detect autocorrelation is the Durbin Watson test.

H0 : ρ=0 (autocorrelations)

H1 : ρ≠0 (not autocorrelations)

Critical value:

Accepted H0, if dU < DW < (4-dU)

Durbin Watson Statistics: $DW = \frac{\sum_{t=2}^n (e_t - e_{t-1})^2}{\sum_{t=1}^n e_t^2}$

Table 3. Durbin Watson Test

R Square	Durbin-Watson
76,33 %	1,03805

Where Durbin-Watson Statistics = 1,0305, while from the Durbin Watson table with the number of variables 5 (p = 5), and the number of observations 14 (n = 14), it is obtained dL = 0.505 and dU = 2.296. Because the Durbin Watson statistical value is between dU and dL, it can be concluded that the Durbin Watson test results are not convincing. So that checking autocorrelation using other methods. One way to detect autocorrelation among residuals can be seen from ACF plotting.

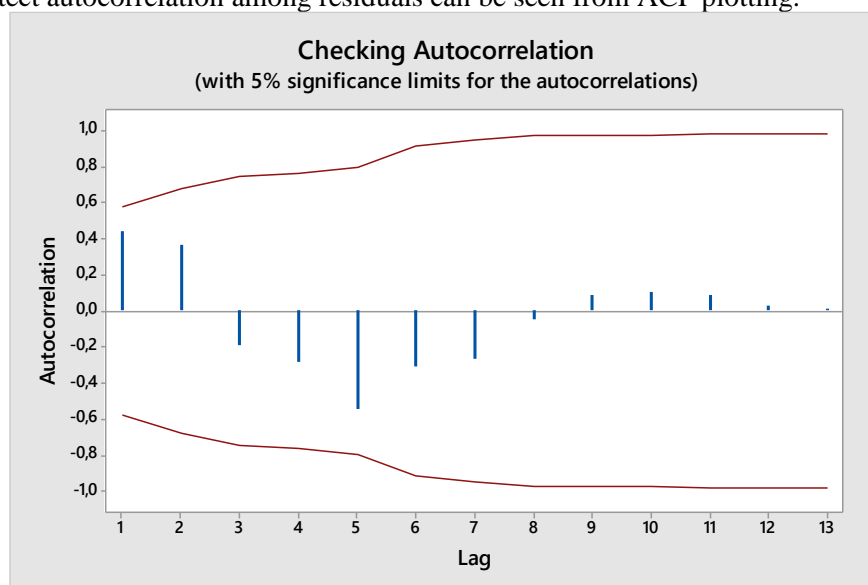


Figure 7. Autocorrelation Plot

Based on the results of the autocorrelation image, it can be seen that no lag that exceeds the red line, where the red line is the upper limit and the lower limit of the autocorrelation line. So it can be concluded that there is no autocorrelation between residues from the t data to the next t-1 data [23].

4) Heteroskedasticity Test

One way to detect the presence or absence of heteroscedasticity is to perform the Glejser test [24]. The Glejser test proposes to regress the absolute value of the residual on the independent variable. Probability results are said to be significant if the significance value is above the 5% confidence level. If the sig value in the Glejser test for each independent variable is <0.05, then there is heteroscedasticity or is called the unequal residual. If the sig value in the Glejser test for each independent variable is > 0.05, then there is no heteroscedasticity or it is called the same residual variance.

Analysis of Variance					
Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	4	252333261	63083315	0,86	0,522
Rainfall	1	222902560	222902560	3,05	0,115
Rainy days	1	73481335	73481335	1,00	0,343
Temperature	1	4652935	4652935	0,06	0,807
Humidity	1	511080	511080	0,01	0,935
Error	9	658663482	73184831		
Total	13	910996743			

Figure 8. Glejser Test

Based on the results of the Glejser test, it is known that the significance value (p-value) of all independent variables after being restored with absolute residual value is above 0.05 so that it can be concluded that the residual variance is the same or there is no heteroscedasticity. Based on the examination of the classical assumptions of the regression, all four have been fulfilled, so that the regression model obtained using the OLS approach is the Best Linear Unbiased Estimator (BLUE).

4 Conclusion

The mathematical model of the analysis of the effect of rainfall, number of rainy days, air temperature, and humidity on NO tobacco production in Jember Regency is as follows.

$$Y = -362629 + 0.1285 \text{ rainfall} + 2.93 \text{ rainy days} + 16630 \text{ temperature} - 1377 \text{ humidity}$$

The coefficient of determination is 76.33%, this shows the influence of the variables of rainfall, number of rainy days, temperature, and humidity resulting in fluctuations in Na-Oogst tobacco production in Jember Regency and 23.67% caused by other factors.

5 Acknowledgments

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