

# Growth and production of Toraja Arabica coffee on different types of planting management

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## Growth and production of Toraja Arabica coffee on different types of planting management

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**Abstract.** This study aims to investigate the growth and productivity of Arabica coffee plants due to different plant maintenance. The research was conducted from November to December 2019 in Lembang Kayuosing, Rembon District, Tana Toraja Regency, South Sulawesi Province. The study used survey and observation methods with questionnaire / interview techniques. Data was analysed based on multiple linear regression using SPSS software. The analysis was used to determine the effect of plant maintenance and different types of shading trees. The maintenance techniques that significantly affect the productivity of Arabica coffee plants in Lembang Kayuosing, Rembon District, Tana Toraja Regency were fertilization methods, fertilization time, shape pruning, and pests and plant diseases control. As for the best type of shade tree that significantly affected coffee plant height and stem diameter was Sengon (*Albizia chinensis*) plant. The productivity of Arabica coffee plants in Lembang Kayuosing, Rembon District, Tana Toraja Regency was 0.47 kg / tree.

### 1. Introduction

Indonesia is an agricultural country, where 40% of the livelihoods of the majority of the population are farming or cultivating crops. The location of the country of Indonesia is in an area with a tropical climate that allows a perfect decomposition process of parental rock material by weather resulted in higher soil fertile and Indonesia become one of the largest coffee producing countries in the world.

The coffee plant is from a genus of *Coffea* which belongs to the Rubiaceae family and has about 100 species. The genus *Coffea* is one of the important genera which has high economic value and is developed commercially, especially *Coffea arabica*, *Coffea liberica*, *Coffea chanephora* and Robusta coffee. The coffee plant is a tropical plant originating from Africa. Even though coffee is a tropical plant, it requires shade trees and does not want high temperatures [1].

South Sulawesi Province, as one of the coffee plantation areas with the status of smallholder plantations, contributes to coffee in Indonesia. Data from the Directorate General of Plantation [2] shows that the total area of planting in South Sulawesi Province in 2017 was around 73,392 hectares with a total production of 30,992 tons and a productivity of 662 kg / ha. The distribution of community plantations covering an area of 71,396 hectares with a total production of 29,902 tons, while large private plantations covering an area of 1,996 ha with production amounted to 1,090 tonnes.

Coffee plants that develop in Indonesia consist of Arabica and Robusta coffee. Both of these coffees have a fairly high level of demand compared to other types of coffee. Both coffees have several problems, especially in terms of productivity. Arabica coffee productivity has only reached 800 kg / ha



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and Robusta coffee of 700 kg / ha. This is different from Liberica which has reached a productivity of up to 1,500 kg / ha. Arabica coffee in Indonesia is still low because if the Arabica coffee plantation area is properly managed, it will produce 2 tonnes / ha and can even reach 3 ton<sup>17</sup> / ha [3].

Coffee production and productivity cannot be separated from the various problems encountered from the upstream to downstream sectors. Some of the problems in the upstream sector include land factors, low productivity of plant material, old plant age so that they are less productive, to the implementation of cultivation techniques. The problems in the downstream sector are mostly caused by poor post-harvest production processing methods, especially in poor fermentation and drying processes so that the quality is not good [4].

Inaccurate implementation of coffee plant cultivation causes crop production to be less than optimal and susceptible to pests and diseases. The problems of various complex aspects of coffee plant cultivation should be handled with an appropriate development model so that the management of good and correct cultivation techniques will increase the productivity of the coffee plant.

Besides that, the arrangement of the type of shade is also very important in coffee cultivation. This is because coffee is a C3 plant, which requires light intensity that is not full in carrying out the photosynthesis process so that coffee plants need shade trees in their growth. Management of shade trees on coffee plants is needed to reduce the bad effects of too hot sunlight and can extend the economic life of the plants. The symbiotic relationship between the types of shade plants and coffee plants is identical to the symbiotic relationship in the concept of mix cropping in which there is a process of interaction or a reciprocal relationship<sup>6</sup> between more than one type of plant grown on the same land [5]. Based on the previous description, it is necessary to conduct research on the effect of the type of shade and maintenance of coffee plants on the growth and productivity of Arabica coffee plants.

## 2. Methodology

This research was conducted in Lembang Kayuosing, Rembon District, Tana Toraja Regency, South Sulawesi Province which took place from November 2019 to December 2019. This research is in the form of surveys and direct observations in the field. The research location was determined based on the age of the plant, namely 15-35 years. The number of respondents in this study were 25 farmers spread over 5 hamlets, namely Lappo '(1 farmer), Panglokkoran (13 farmers), Pangala' (1 farmer), Lo'ko 'Lemo (6 farmers), and Tombang Bai (4 farmers).

### 2.1. Types of data and research stages

The data used in this study consisted of primary data and secondary data. Primary data were obtained through interviews and filling out questionnaires to coffee farmers in Rembon District. Secondary data were obtained from BPS / Dinas / Lembang Kayuosing Office, relevant previous research results and literature sources.

The data were obtained through several methods namely survey, observation, interview, literature study, and documentation. The survey method is used to collect data or information about the population. According to Irawan [6], the survey method is a research method that uses a questionnaire as the main instrument for collecting data. Observation was conducted by observing directly the conditions of the field / research object so that the real conditions can be obtained. Conducted on the condition of coffee gardens and cross-check<sup>11</sup> on the effect of species and maintenance on coffee plant productivity. Interview technique is a form of structured questions given to respondents according to the research problem. Conducted on respondents (farmers) to obtain the desired data and information. The literature study was conducted by collecting information from existing references or knowledge by studying or reading literature related to the subject of research. In addition, documentation was carried<sup>12</sup> out on supporting data obtained through relevant agencies as a complement to research. The sampling technique used purposive sampling. According to Sugiyono [7], purposive sampling is a technique of sampling data sources with certain considerations (such as: location and respondents).

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2.2. Data analysis method

Data analysis in this study was performed using the SPSS Software. Data obtained from the field are generally qualitative in nature, before being analyzed with multiple linear regression analysis through the SPSS software, a scoring was carried out on the shading factors and the coffee plant maintenance techniques. Scores are given for each factor of shade and plant maintenance based on the results of interviews, literature studies and observations presented in tabular form. Two data analysis was employed namely T statistical test using excel software, and multiple linear regression data analysis. Data obtained were analyzed using the t test to study the effect of different types of shade trees (Sengon (*Albizia finensis*); Dadap (*Gliricidia sepium*); Lamtoro (*Leucaena glauca*); and Gamal (*Gliricidia sepium*)) on the growth and productivity of Arabica coffee plants. The growth variables observed were coffee plant height, stem diameter, and plant productivity. On the other hand, the multiple linear regression used to determine the effect of plant maintenance aspects on the growth and productivity of coffee plants.

According to Aris [8] the form of the multiple linear type production function can be expressed as:

$$Y = a + bX_1 + cX_2 + dX_3 + eX_4 + fX_5 + gX_6 + hX_7 + iX_8 + jX_9$$

Where Y = Plant Productivity (output quantity); X1 = Dose of Fertilizer; X2 = Frequency of Fertilization; X3 = Fertilization Method; X4 = Time of Fertilization; X5 = Shape Pruning; X6 = Production Pruning; X7 = Rejuvenation Pruning; X8 = Sanitation; and X9 = Disease Pest Control

3. Results

3.1. Effect of Arabica coffee plant maintenance on productivity

Arabica coffee production and productivity in Lembang Kayuosing, Rembon District, Tana Toraja Regency were analyzed using multiple linear regression. Nine variables were tested including fertilizer dose, frequency of fertilization, fertilization method, time of fertilization, shape pruning, production pruning, rejuvenation pruning, sanitation, pests and diseases control in affecting the productivity (table 1).

Table 1. Results of multiple linear analysis effect of plant maintenance on plant productivity.

Regression Model	Regression coefficient	Probability	Significance
Constant	149.037	0.330	
Fertilizer dose	1.657	0.966	ns
Frequency of Fertilization	8.172	0.519	ns
Fertilization method	32.751	0.010	*
Time of fertilization	34.178	0.044	*
Shape pruning	38.133	0.016	*
Production Pruning	13.269	0.659	ns
Rejuvenation pruning	5.147	0.739	ns
Sanitation	14.107	0.657	ns
Pest and disease control	23.399	0.046	*

ns= variable did not have a significant effect on plant productivity, \* = variable has a significant effect on plant productivity. Processed primary data, 2020.

Based on the results of data analysis, the multiple linear regression equation of the effect of variables fertilizer dose (X1), fertilization frequency (X2), fertilization method (X3), time of fertilization (X4), shape pruning (X5), production pruning (X6), rejuvenation pruning (X7), sanitation (X8), and pest and disease control (X9) on productivity (Y) was:

$$Y = 149.037 + 1.657X_1 + 8.172X_2 + 32.751X_3 + 34.178X_4 + 38.133X_5 + 13.269X_6 + 5.147X_7 + 14.107X_8 + 23.399X_9$$

The multiple linear regression equation above means:

1. The value of 149.037 is the value of plant productivity if the nine independent variables are considered constant.
2. The value 1.657 is the value that indicates the productivity will increase by 1.657% if there is an increase of 1 level in the fertilizer dose.
3. The value of 8.172 is the value that indicates productivity will increase by 8.172% if there is an increase of 1 level in the frequency of fertilization.
4. Value 32.751 is the value that indicates productivity will increase by 32.751% if there is an increase of 1 level in the fertilization method.
5. The value 34.178 is the value that shows the productivity will increase by 34.178% if there is an increase of 1 level at the time of fertilization.
6. The value 38.133 is the value that shows the productivity will increase by 38.133% if there is an increase of 1 level in the shape trimming activity.
7. The value 13.269 is the value that indicates the productivity will increase by 13.269% if there is an increase of 1 level production cutting activities.
8. Value 5.147 is the value that indicates productivity will increase by 5.147% if there is an increase of 1 level in the rejuvenation pruning activity.
9. The value of 14.107 is the value that indicates that productivity will increase by 14.107% if there is an increase of 1 level in sanitation activities.
10. A value of 23.399 is a value that indicates that productivity will increase by 23.399% if there is an increase of 1 level in pest and disease control activities.

The coefficient of determination ( $R^2$ ) is useful for measuring the ability of the independent variable to explain or influence the dependent variable. The coefficient of determination ranges from 0 to 1. If the coefficient of determination is close to 1, it means that the influence of the independent variable on dependent variable is getting stronger, and vice versa when the coefficient of determination approaches 0, the effect of the independent variable on the dependent variable is getting weaker.

**Table 2.** The coefficient of determination of the effect of maintenance techniques on productivity.

Model	Change Statistics						
	R Square	Adjusted R Square	R Square Change	F Change	df1	df2	Sig. F Change
1	.881	.810	.881	12.394	9	15	.000

- a. Predictors: (Constant), Fertilizer Dose, Fertilization Frequency Fertilization Method, Time of Fertilization, Shape Pruning, Production Pruning, Rejuvenation Pruning, Sanitation, and Pest and Disease Control.
- b. Dependent Variable: Plant Productivity

Primary data after processing, 2020.

Based on the results of data analysis using multiple linear regression, the coefficient of determination  $R^2$  was obtained at 0.881 (table 2), which means that 88.1% of the productivity of the Arabica coffee plant is influenced or described as predictors (constant), while the remaining 11.9% is influenced or explained by other variables outside the variable used.

The results of simultaneous test with the F-test is used to determine how the influence of all independent variables together on the dependent variable. The F test basically shows whether all the dependent variables included in the model have an overall effect on the dependent variable as shown in the table 3.

**Table 3.** F test results of the effect of maintenance techniques on plant productivity.

Model	Sum of Squares	Df	Mean Square	F	Sig.
1 Regression	298522.206	9	33169.134	12.394	.000 <sup>a</sup>
Residual	40141.794	15	2676.120		
Total	338664.000	24			

a. Predictors: (Constant), Fertilizer Dose, Fertilization Frequency Fertilization Method, Time of Fertilization,

Shape Pruning, Production Pruning, Rejuvenation Pruning, Sanitation, and Pest and Disease Control.

b. Dependent Variable: Plant Productivity.

Primary data after processing, 2020.

The T-test, known as the partial test, is used to determine how much the effect of each fertilizer dose, fertilization method, frequency of fertilization, time of fertilization, pruning, rejuvenation, sanitation and HPT control on the productivity of Arabica coffee plants is presented in the table 4.

**Table 4.** T-test results of the effect of maintenance techniques on productivity.

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1 (Constant)	149.037	148.188		1.006	0.330
Fertilizer dose	1.657	38.221	0.010	0.043	0.966
Frequency of Fertilization	9.172	12.389	0.118	0.660	0.519
Fertilization method	32.751	11.104	0.443	2.949	0.010
Time of fertilization	34.178	15.560	0.489	2.197	0.044
Shape pruning	38.133	14.068	0.472	2.711	0.016
Production Pruning	13.269	29.468	0.055	0.450	0.659
Rejuvenation pruning	5.147	15.153	0.049	0.449	0.739
Sanitation	14.107	31.182	0.059	0.452	0.657
Pest and disease control	23.399	10.729	0.258	2.181	0.046

a. Dependent Variable: Plant productivity.

Source: Primary data after processing, 2020.

Based on the results of the T-test data analysis using multiple linear regression, it shows the p-value of each factor of maintenance technique, if the p value is <0.05, the independent variable has a significant effect, and vice versa if the p value > the 0 level value. ,05 then the effect of the independent variables does not have a significant effect. The T-test that was carried out indicates the following:

1. The fertilizer dose variable has a probability value of  $0.966 > 0.05$  which means it is not significant, or  $H_0$  which states that there is no significant effect between the dose of fertilizer on the productivity of coffee plants is accepted. This means that the dose of fertilizer does not significantly affect the productivity of Arabica coffee plants.
2. The variable of fertilization method has a probability value of  $0.519 > 0.05$  which means that it is not significant, or  $H_0$  which states that there is no significant influence between the method of fertilization on the productivity of the coffee plant is accepted. This means that the fertilization method does not significantly affect the productivity of Arabica coffee plant.
3. The variable frequency of fertilization has a probability value of  $0.010 < 0.05$ , which means that it is significant, or  $H_0$  which states that there is no significant effect between the frequency of fertilization on coffee productivity. In conclusion, the frequency of fertilization has a significant effect on the productivity of the Arabica coffee plant.
4. The variable of time of fertilization has a probability value of  $0.044 < 0.05$ , which means that it is significant, or  $H_0$  which states that there is no significant effect between the time of fertilization on the productivity of coffee rejected. In conclusion, the time of fertilization has a significant effect on the productivity of the Arabica coffee plant.
5. The shape trimming variable has a probability value of  $0.016 < 0.05$  which means significant, or  $H_0$  which states that there is no significant effect between shape trimming on coffee productivity is rejected. In conclusion, shape pruning has a significant effect on the productivity of the Arabica coffee plant.
6. Production pruning variable has a probability value of  $0.659 > 0.05$  which means it is not significant, or  $H_0$  which states that there is no significant effect between production cuts on coffee plant productivity is accepted. This means that production cuts do not significantly affect the productivity of the Arabica coffee plant.
7. Rejuvenation pruning variable has a probability value of  $0.739 > 0.05$  which means it is not significant, or  $H_0$  which states that there is no significant effect between rejuvenation pruning on coffee plant productivity is accepted. This means that rejuvenation pruning does not significantly affect the productivity of the Arabica coffee plant.
8. The sanitation variable has a probability value of  $0.657 > 0.05$  which means it is not significant, or  $H_0$  which states that there is no significant effect between sanitation on the productivity of coffee plants is accepted. This means that sanitation does not have a significant effect on the productivity of the Arabica coffee plant.
9. Pest and disease control variables have a probability value of  $0.046 < 0.05$  which means significant, or  $H_0$  which states that there is no significant effect between pest and disease control on coffee productivity. In conclusion, pest and disease control has a significant effect on the productivity of Arabica coffee plants.

### 3.2. Effect of shade types on growth and productivity

The effect of shade types on the growth and productivity of Arabica coffee was analyzed using statistical tests with excel software on four variables of the types of shading trees namely Sengon (*Albizia chinensis*); Dadap (*Gliricidia sepium*); Lamtoro (*Leucaena glauca*); and Gamal (*Gliricidia sepium*). The effect of shade trees on the stem diameter of the Arabica coffee is shown in table 5.

The results of the T-test in table 5 shows that the inter-variable testing has a significant effect on the sengon-lamtoro and dadap-lamtoro variables on the productivity of the Arabica coffee plant. The type of shade that gave the largest average stem diameter was found in the use of Sengon (*Albizia chinensis*) shade, namely 5.41 cm.

The t-test of the comparison of the effect of shade types on plant height is shown in table 6. The results of the T-test in table 6 show that the inter-variable testing has a significant effect on the sengon-lamtoro and sengon-gamal variables on the height of the Arabica coffee plant. The type of shade that gives the largest average plant height is the use of Sengon (*Albizia chinensis*) shade, namely 16.40 m.

**Table 5.** Comparison of the effect of shade type on stem diameter (cm).

Shading tree	T STAR	TABLE T		Mean	Sig.
		0.05	0.01		
Sengon Dadap	4.724	1.81	2.23	5.41 4.61	**
Sengon Lamtoro	2.126	1.86	2.31	5.41 4.64	*
Sengon Gamal	3.654	1.81	2.23	5.41 4.72	**
Dadap Lamtoro	4.635	1.83	2.26	4.61 4.64	**
Dadap Gamal	0.567	1.81	2.23	4.61 4.72	ns
Lamtoro Gamal	2.154	1.83	2.26	4.64 4.72	*

Sengon: *Albizia chinensis*; Lamtoro: *Leucaena glauca*; Gamal: *Gliricidia sepium*; Dadap: *Gliricidia sepium*. \*= significant, \*\*= highly significant, ns= not significant.  
Primary data after processing, 2020.

**Table 6.** Comparison of the effect of shade types on plant height (m).

Shading tree	T STAR	TABLE T		Mean	Sig.
		0.05	0.01		
Sengon Dadap	3.245	1.86	2.31	16.40 14.71	**
Sengon Lamtoro	2.141	1.89	2.36	16.40 12.59	*
Sengon Gamal	2.184	1.83	2.26	16.40 11.98	*
Dadap Lamtoro	3.245	1.83	2.26	14.71 12.59	*
Dadap Gamal	2.13	1.81	2.23	14.71 11.98	*
Lamtoro Gamal	0.437	1.86	2.31	12.59 11.98	ns

Sengon: *Albizia chinensis*; Lamtoro: *Leucaena glauca*; Gamal: *Gliricidia sepium*; Dadap: *Gliricidia sepium*. \*= significant, \*\*= highly significant, ns= not significant.  
Primary data after processing, 2020.

15 The results of the T-test of the effect of shade types on the productivity of coffee plant is shown in table 7. The results show that the inter-variable testing has a very significant effect on the sengon-dadap, sengon-lamtoro, dadap-lamtoro variables on the productivity of the Arabica coffee plant. The type of shade that gave the highest average productivity was found in the use of Sengon (*Albizia chinensis*) shade, which was 600 grams.

**Table 7.** Comparison of the effect of shade types on productivity (g).

Shading tree	T STAR	TABLE T		Mean	Sig.
		0.05	0.01		
Sengon	2.506	1.89	2.36	600.0	**
Dadap				486.6	
Sengon	7.268	1.83	2.26	600.0	**
Lamtoro				375.0	
Sengon	2.565	1.94	2.45	600.0	*
Gamal				413.3	
Dadap	2.312	1.85	2.3	486.6	**
Lamtoro				375.0	
Dadap	2.565	1.81	2.22	486.6	**
Gamal				413.3	
Lamtoro	1.717	1.85	2.30	375.0	ns
Gamal				413.3	

Sengon: *Albizia chinensis*; Lamtoro: *Leucaena glauca*; Gamal: *Gliricidia sepium*; Dadap: *Gliricidia sepium*. \*= significant, \*\*= highly significant, ns= not significant.  
Primary data after processing, 2020.

#### 4. Discussion

##### 4.1. Fertilizer dose

The coffee plant needs to be fertilized in order to increase production and yield quality, as well as maintain high production stability. In areas with high rainfall, it is better if more than twice to speed up the washing of fertilizers [9].

Giving the right dose of fertilizer will increase soil fertility which will cause the level of plant productivity to be more stable and increase plant resistance to disease and can improve the condition and resistance of plants to extreme environmental changes, such as shortages and too dense fertilization, increase production and yield quality, as well as maintaining high production stability [10].

Table 1 shows that the fertilizer dose carried out by the farmer has a probability value = 0.966 > 0.05 which does not have a significant effect (not real). This shows that the application of various fertilizer doses to Arabica coffee plants in the research location has no significant effect on the productivity of Arabica coffee plants as the opinion of the Directorate General of Plantation [10] states that organic fertilizer is given twice a year with a dose of organic fertilizer, namely 10 - 20 kg / tree / year. And according to the Coffee and Cocoa Research Center (2006), the ingredients for Arabica coffee plants that increase the fertilization dose for plants over 10 years old are 200 grams of urea, 100 grams of SP36, 125 grams of KCl and 70 grams of kieserit for fertilization at the beginning and end of the rainy season.

Balanced fertilization is very important in increasing the production and productivity of Arabica coffee. Some of the nutrients needed in large quantities are called macro nutrients, namely N, P, K, S, Ca, and Mg, while the nutrients needed in small amounts are called micro elements, namely Cl, Fe, Mn, Cu, Zn, Bo and Mo. The need for the type and dose of fertilizer in Arabica coffee plants is also influenced by the growth and development phase. This is in accordance with what was stated by Matta et al (2007), that the optimal dose and efficient enough for the growth and yield phase is the dose of Phosphorus (P) fertilizer, while to find out the optimal dose for efforts to improve the quality of seed yields, it is recommended to increase the level of fertilizer dosage or with a combination of more potassium (K) fertilizer.

#### 4.2. Fertilization frequency

Table 1 shows that the frequency of fertilization carried out by farmers has a probability value = 0.519 > 0.05 which does not have a significant effect (not significant). This shows that the frequency of fertilization by the respondent farmers has no significant effect on the productivity of the coffee plant. The frequency of fertilization carried out by farmers in the research locations varies, some do fertilization twice a year, some do up to three times, some even once there are some farmers who do not fertilize their coffee plants.

The frequency of fertilization for the Arabica coffee plant is very important to support the productivity of the coffee plant itself and in addition, so that farmers do not waste fertilizer too often due to frequent fertilization. As stated by Martini and Hulupi [9], proper and proper coffee plant fertilization is done by giving it twice a year, at the beginning and end of the rainy season.

#### 4.3. Fertilization method

One of the factors that determine the effectiveness of fertilization is the proper way of giving. The right way of applying fertilizers will have a more good effect on plants and vice versa if the method is done incorrectly then fertilization will not affect the plants, this is in line with the opinion of Nasaruddin [11] that the way of placing and applying fertilizers is not correct will result in the amount of fertilizer. which is given can be absorbed by plants to be very low, loss of fertilizer through evaporation, run off due to erosion and washing (lecing) becomes very high.

Table 1 shows that the fertilization method used by farmers has a probability value = 0.010 < 0.05, which indicates a significant effect. This shows that the fertilization method used by the respondent farmers has a significant effect on the productivity of the coffee plant. The fertilization method used by farmers in the research locations varies, namely sowing and digging holes around the stems of the plant, this is in accordance with the opinion of Firmansyah [12] that the method of applying fertilizers follows the distance and plant arrangement, i.e. if the distance between plants is more than 1 m, the fertilizer is placed in a groove 30-40 cm circular from the main stem, depth of placement 2 - 5 cm.

#### 4.4. Time of fertilization

The time of fertilization carried out by the farmer has a probability value = 0.044 < 0.05 which indicates a significant effect. This shows that the time of fertilization by the respondent farmer has a significant effect on the productivity of the coffee plant. The fertilization conducted by respondent farmers namely at the beginning and end of the rainy season

Good fertilization is carried out twice, namely the beginning and end of the rainy season so that it will have a significant effect on plant productivity, this is in accordance with the opinion of Adnyana [13] that the need for fertilizer for coffee plants varies and increases with increasing age of coffee plants, fertilizer is given twice a year, namely at the beginning and end of the rainy season. Plants that get the optimum amount of nutrients and at the right time will grow and develop optimally.

#### 4.5. Shape pruning

Shape pruning done by the farmer has a probability value = 0.016 < 0.05 which indicates a significant (real) effect. This shows that the shape pruning done by the respondent farmer has a significant effect on the productivity of the coffee plant. Shape pruning aims to create an ideal tree shape, form a stronger and more balanced plant framework, this is in accordance with Kahpi's [1] opinion that shape pruning is done by cutting the tops of the coffee plants so that the coffee plants do not grow too tall and are also useful for branches, while primary branches can extend sideways.

#### 4.6. Production pruning

Production pruning made by farmers have a probability value = 0.659 > 0.05 which states that they do not have a significant effect. This shows that the production cut by the respondent farmers has no significant effect on the productivity of the coffee plant. Pruning production, aims to trim unproductive

branches or old branches. This is done so that the plant is more focused on growing productive branches. In addition, pruning is also to remove branches that are affected by disease or pests [14].

#### 4.7. Rejuvenation pruning

Rejuvenation pruning carried out by farmers has a probability value = 0.739 > 0.05 which states that it does not have a significant effect (not real). This shows that the rejuvenation pruning done by the respondent farmers has no significant effect on the productivity of the coffee plant. In this case, the age of Arabica coffee in the research location is more than 30 years old and no farmer has made rejuvenation pruning. As stated by Wachjar [14], rejuvenation pruning is carried out on plants that have experienced a decline in production, yields of less than 400 kg / ha / year or canopy shapes that are already irregular. Pruning is done after fertilizing to maintain nutrient availability.

#### 4.8. Sanitation

A probability value = 0.657 > 0.05 on the activity of sanitation conducted by farmers indicates that there is no significant effect of this maintenance on the productivity of coffee plant. This shows that sanitation activities carried out by respondent farmers have no significant effect on coffee plant productivity.

Sanitation activities are one of the important things in the management of coffee plantation areas to prevent plants from pests and diseases. Sanitation activities carried out by respondent farmers in the research location were controlling weeds. Weed control by farmers depends on how many weeds are growing. Coffee plants must always be clean of weeds, especially when the plants are young. Weed control also plays an important role in reducing pests and diseases, this is in accordance with the opinion of Wachjar [14] that weeds under coffee trees will become competitors for nutrients, sunlight, water and space, and help spread pests and diseases.

Apart from that, other sanitation activities carried out were collecting the leftover trash or coffee skins. In this case, the respondent farmer only collects waste and does not process it further using compost. The skin and coffee leaf rubbish that is collected is sometimes piled up even in one place so that rotten coffee beans become a nesting place for diseases that can disturb other coffee plants.

#### 4.9. Pest and disease control

Table 1 shows that the pest and disease control activities carried out by farmer have a probability value = 0.046 > 0.05 which states that they have a significant effect. This shows that the pest and disease control activities carried out by the respondent farmers have a significant effect on the productivity of coffee plants.

Pest and disease control carried out by respondent farmers at the research location mostly uses chemicals. In addition to using chemicals, farmers carry out mechanical control by cutting branches or removing parts of plants that are attacked by pests or diseases and there are also those who combine chemically, mechanically and biologically. This happens because the dominant pests that interfere with the farmers' coffee plants are stem borer, besides that there are also coffee berry borer (CBB). The diseases that attack the coffee plants of the respondent farmers are fungus, rust and fruit powder.

Farmers control pests and diseases so that plant productivity is higher and can increase the resilience of Arabica coffee plants even though the plant is old, this is in accordance with the opinion of Hami et al. [15] that control of pests and diseases of coffee plants is aimed at suppressing the development of pest and pathogen populations. so as not to be economically detrimental and to increase plant resilience. Control components include the use of resistant varieties, technical, biological or biological cultures, synthetic and vegetable pesticides.

#### 4.10. Effect of shade types on growth and productivity

The coffee plant is a C3 plant that requires shade, especially for planted land which is given limited water and fertilizer. Shade trees act as a buffer against environmental factors that are less than optimal to support plant growth and productivity. The use of shade trees has many benefits including reducing

light intensity and sun heat, regulating humidity, suppressing weed growth and also being a source of organic material for coffee plants.

Table 5, 6, and 7 show that the type of shade with the highest effect on plant growth and productivity is the Sengon tree (*Albizia chinensis*). Sengon shade is very useful for plant growth because it is a plant that can fix nitrogen. This is in accordance with the opinion of Musa et al. [3] that sengon is a legume tree (nitrogen fixing plant) that can fix nitrogen or N<sub>2</sub>, and sengon is symbiotic with Rhizobium. N<sub>2</sub> is a nutrient that is needed by plants in the growth process.

Sengon plant is a type of legume plant whose leaves and twigs can be used as litter which can be used as organic material that can increase soil fertility. This is in accordance with the opinion of Khalif et al. [16] that the presence of sengon plants can improve the quality of soil fertility as indicated by an increase in organic matter input, soil organic matter content, total N. There was an increase in soil N in the land with sengon planting due to the higher input of organic matter.

Apart from the sengon plant, the gamal (*Gliricidia sepium*) tree was also very influential on the plant height of the coffee plant. Gamal can be used as green manure which can increase soil fertility and have an effect on plant growth. In accordance with the opinion of Kon [17] that gamal leaves contain a lot of protein. In addition, the leaves and twigs on the gamal plant can also be used as green manure which is useful for improving soil fertility.

The type of lamtoro (*Leucaena glauca*) shade had the lowest average productivity of coffee plants compared to the sengon type which had a high average productivity. Differences in the shape and size of leaves and crowns affect the amount of light intensity that is passed to the coffee plant so that it affects the photosynthesis process. This type of lamtoro shade will cause the entry of high light intensity because the shape and size of the leaves are smaller and less dense than the sengon shade plant. This can reduce the productivity of coffee plants. In accordance with the opinion of Ristiawan [18] that coffee production depends on environmental conditions and many other factors that influence it. The optimum environmental conditions for coffee will lead to sustainable high production. Different light intensities cause different productivity of coffee plants. In high light intensity, production can be higher but it is not sustainable if it is not supported by high nutritional intake. The use of a shade that provides a light intensity of not more than 60% allows optimum environmental conditions and high and sustainable coffee production.

### 13 Conclusion

Based on the results of research that has been conducted on the growth and productivity of Toraja Arabica coffee on various types of shade and maintenance, it can be concluded that:

- The productivity of Arabica coffee in Lembang Kayuosing, Rembon District, Tana Toraja Regency is 0.47 kg per tree.
- Coffee plant maintenance techniques such as frequency of fertilization, timing of fertilization, form pruning, and pest and plant disease control have a significant effect, while the variable fertilizer dosage, fertilization methods, cutting production, pruning, rejuvenation, and sanitation have no significant effect on the productivity of Arabica coffee plants in Lembang Kayuosing, Rembon District, Tana Toraja Regency.
- The type of shade that affects the growth and productivity of arabica coffee plants in Lembang Kayuosing, Rembon District, Tana Toraja Regency is sengon shade where this type of shade has a large average value for the diameter of the coffee plant stem, the height of the coffee plant, and the productivity of the plant. Arabica coffee.

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