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COMPARISON OF COFFEE FARMING WITH MONOCULTURE AND POLYCULTURE CROPPING PATTERNS IN KARO REGENCY (CASE STUDY IN TIGA PANAH DISTRICT AND BARUSJAHE DISTRICT)

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Abstract

Karo Regency is one of the coffee growing centers in Indonesia. Karo Regency is a regency in North Sumatra Province. Several sub-districts produce the most coffee and have the largest land area, namely Tiga Panah and Barusjahe Districts. In addition to coffee, Karo Regency is a major center for vegetables, especially cabbage. To increase farmers' incomes, given their limited land and planting area, farmers must increase the production of each coffee plot. One way to do this is through polyculture planting, which involves intercropping coffee plants. The purpose of this study was to comparatively analyze coffee farming practices that implement monoculture and polyculture in Karo Regency and to determine the factors that influence coffee farmers' income in both cropping patterns and the influence of cropping patterns on the long-term sustainability of coffee farming. The research design used was comparative quantitative research. The method for determining the location in the study used purposive sampling and simple random sampling. The sample in this study were coffee farmers in Karo Regency who implement monoculture and polyculture cropping patterns. with a total of 60 people, 30 farmers cultivate monoculture coffee plants and 30 polyculture coffee farmers spread across 2 (two) sub-districts, namely Tiga Panah Sub-district and Barusjahe Sub-district.

Keywords: ***Comparison, Farming, Monoculture and Polyculture***

INTRODUCTION

The plantation sector is the most promising sector for generating substantial profits compared to other agricultural sectors. This is because the crops cultivated are export commodities in high demand, both for domestic and international consumption. One plantation commodity widely cultivated in Indonesia is coffee. According to Rahardjo (2012). Coffee is one of the most valuable plantation materials. It is very economical and plays an important role compared to other plantation crops. One of Indonesia's coffee growing centers is located in Karo Regency, North Sumatra Province, with an area of 44.65 km2. The highest point in Karo Regency is Naman Teran District, while the lowest point is Laubaleng District. (Karo Regency in Figures, 2024) Geographically, Karo Regency is located between 2.500–3.190 North Latitude and 97.550–98.380 East Longitude with an area of 2,127.25 km2 or 2.97 percent of the area of North Sumatra Province. Karo Regency is located in the Bukit Barisan range and most of its area is a plateau. Two active volcanoes are located in this area so it is prone to volcanic earthquakes. The Karo Regency area is at an altitude of 200–1,500 M above sea level. To the north it borders Langkat Regency and Deli Serdang Regency, to the south it borders Dairi Regency and Samosir Regency, to the east it borders Deli Serdang Regency and Simalungun Regency and to the west it borders Nangroe Aceh Darussalam Province (Karo Regency in Figures, 2024).

Table 1. Data on Land Area and Coffee Production in North Sumatra Province, 2021

Regency/ City	Arabica Coffee					
	Planted Area (Ha)			Production (Tons)		
	2018	**2019**	**2020**	**2018**	**2019**	**2020**
Mandailing Natal	3554	3554	3564	2332	2332	2533
South Tapanuli	4608	4608	4606	2098	2098	2103
Samosir	5058	5058	5064	4157	4157	4163
North Tapanuli	16467	16467	16468	15213	15213	15222
Toba Samosir	4784	4784	4788	4187	4187	4403
West Pakpak	959	959	964	1085	1085	1084
Simalungun	8217	8217	8233	10324	10324	10523
Dairi	12088	12088	12099	9612	9612	9613
Karo	**9198**	**9198**	**9205**	**7402**	**7402**	**7403**
Deli Serdang	713	713	711	666	666	663
Langkat	75	75	75	78	78	78
Humbang Hasundutan	12044	2044	12057	9677	9677	9683

Source: North Sumatra Provincial Plantation Service, 2021

Table 1 shows that the land area and production volume of Arabica coffee in North Sumatra Province have increased, reaching 77,834 hectares in 2020, with a total production volume of 67,469 tons. Karo Regency also experienced an increase in land area and production volume, reaching 9,205 hectares in 2020, with a total production volume of approximately 7,403 tons.

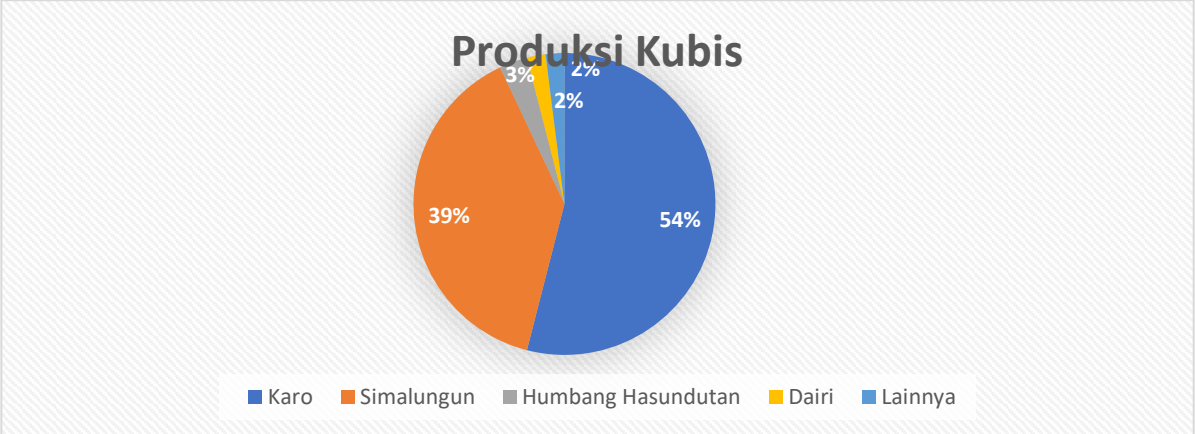
Table 2. Data on Coffee Production Amount and Area of People's Plantations in Karo Regency, 2021.

Subdistrict	Coffee Production (Tons)	Land Area (Ha)
	2021	
Mardingding	122.00	120.00
Laubaleng	-	-
Three-dimensional	20.00	36.00
Juhar	208.00	389.00
Munte	794.00	757.50
Kutabuluh	358.00	323.00
Umbrella	583.00	552.00
Tiganderket	123.00	142.00
4-way intersection	932.00	1,025.00
Name Teran	303.00	427.00
Independent	158.00	207.00
Kabanjahe	132.00	343.00
Berastagi	108.00	155.00
Three arrows	**1,410.00**	**2,041.00**
People's Dollar	224.00	275.00
Brand	954.00	995.50
Barusjahe	**982.00**	**1,421.00**
Karo	7,411.00	9,210.00

Source: Karo Regency Agriculture Service, 2022

Table 2 shows that in 2021, coffee production in Karo Regency reached 7,411 tons, with smallholder plantations totaling 9,210 hectares. Several sub-districts produce the most coffee and have the largest plantation areas, namely Tiga Panah and Barusjahe. Laubaleng is the only sub-district that does not produce coffee, and is the lowest-lying area in Karo Regency. In addition to coffee, Karo Regency is a major vegetable producer, particularly cabbage, in North Sumatra Province. According to the Statistics Indonesia (BPS) of North Sumatra Province (2018), the central regencies for cabbage crops in North Sumatra Province are Karo Regency, Simalungun Regency, Humbang Hasundutan Regency, and Dairi Regency, which contribute 97.08% of North Sumatra Province's total production. Karo Regency's contribution to North Sumatra Province's cabbage production is 54%, making it the primary center of cabbage production in North Sumatra Province.

Figure 1. Districts with Cabbage Production Centers in North Sumatra Province, 2017



Source: BPS North Sumatra 2018

Demand for cabbage from Karo Regency is quite high, as evidenced by the high intensity of exports and domestic trade. According to the Statistics Indonesia (BPS) (2019), cabbage from Karo Regency is exported to Malaysia, Singapore, Taiwan, Japan, and South Korea. Domestic markets include areas around North Sumatra and Java. Limited land and planting areas force farmers to increase production per coffee plot. Every effort is made to increase coffee productivity. Monoculture cultivation carries significant risks, necessitating diversification of farming practices so that farmers do not rely solely on coffee harvests. To increase farmer incomes, given limited land and planting areas, farmers must increase production per coffee plot. Various methods are employed to address various challenges, from volatile market price fluctuations to increasingly extreme climate change. Efforts to increase farmer productivity and income have been undertaken, one of which is implementing appropriate cropping patterns.

The risks of monoculture farming are very high, so diversification of farming practices is necessary so that farmers do not rely solely on coffee. One way to achieve this is through polyculture, which involves intercropping coffee plants, which can also reduce the risk of crop failure. In addition to improving coffee quality and productivity, intercropping can also increase farmer income. The most common type of intercropping is intercropping with annual crops due to its ease of cultivation, low risk, and quick yield. Common annual crops used with coffee include tomatoes, cayenne peppers, red peppers, corn, and even horticultural crops such as mustard greens and cabbage. The polyculture system is an effective crop cultivation technique for increasing productivity at a low cost while reducing expenses. Intercropping offers advantages for farmers with limited land, such as increasing the harvestable yield per unit area compared to growing a single crop with the same level of management.

Coffee farming by implementing monoculture and polyculture patterns will be influenced by basic elements such as land, labor, capital, and management, thus affecting the income of farmers who implement monoculture patterns with the income of farmers who implement polyculture patterns.

In Karo Regency, farmers are often found using coffee polyculture techniques with seasonal crops to increase their income. For example, in the two sub-districts with the highest coffee production in Karo Regency, Tiga Panah and Barusjahe, where coffee farming practices are not limited to monoculture, as is the case with most coffee commodities, but also polyculture, namely intercropping with crops (brassicas) such as cabbage and mustard greens. This is the basis for researchers to conduct research in 2 (two) sub-districts that produce the most coffee in Karo Regency, namely Tiga Panah Sub-district and Barusjahe Sub-district to see the comparative level of monoculture coffee and polyculture coffee businesses with brassica plants, and also to find out the factors that influence the income

of coffee farmers in both planting patterns and the influence of planting patterns on the sustainability of coffee farming businesses in the long term.

1.1. Formulation of the problem

Based on the description of the background above, the following problem formulation can be obtained:

1. Which is more profitable from a farming perspective, monoculture or polyculture planting patterns for coffee farmers in Karo Regency?
2. Is there a significant difference between the income levels of coffee farmers who apply monoculture or polyculture planting patterns in Karo Regency?
3. What production factors influence coffee farming in monoculture and polyculture coffee cultivation techniques?
4. Which cropping pattern is more economically efficient in the long run? Monoculture or polyculture?

1.2 Objective

This study aims to comparatively analyze coffee farming practices that implement monoculture and polyculture planting patterns in Karo Regency, with the hope of providing relevant recommendations to improve farmer welfare and the sustainability of the coffee sector in this area.

1.3 Benefit

1. The results of the research are expected to be used as a development of scientific knowledge for researchers as a result of direct observation in the development of coffee commodities in Karo Regency.
2. To provide information as a reference for further researchers.

RESEARCH METHOD

The research location was conducted in 2 (two) sub-districts with the highest coffee production in Karo Regency, namely Tiga Panah Sub-district and Barusjahe Sub-district, North Sumatra Province. The population in this study were coffee farmers in Karo Regency. The sampling method was accidental sampling, a sampling technique based on spontaneity factors, meaning anyone who accidentally meets the researcher and fits the characteristics of the research can be used as a sample (respondent). The sample in this study were coffee farmers in Karo Regency who apply monoculture and polyculture planting patterns. with a total of 60 people, 30 farmers who cultivate monoculture coffee plants and 30 people who cultivate polyculture coffee. The data collected were primary data and secondary data. Primary data were obtained from direct interviews with coffee farmers using a pre-prepared questionnaire. Secondary data were obtained from bibliographic studies, books and journals, statistical data from agencies related to the research being conducted. The research design used was comparative quantitative research. Quantitative research is research based on the philosophy of positivism or based on exact science. Its use is to research a particular population or sample, data collection with research instruments, quantitative or statistical data analysis (Sugiyono, 2010).

Data analysis is used to interpret the data that has been collected and then used as a basis for making a decision, namely (1) Analysis of the Cost of Monoculture and Polyculture Farming Businesses. To determine the amount of costs, income and R / C of monoculture and polyculture coffee farming, a descriptive analysis is carried out using the following formula: Cost Analysis According to Sukartawi (2006), to calculate the amount of total costs (total cost) is obtained by adding fixed costs (Fixed cost/FC) with variable costs (Variable cost/VC) with the formula: TC = FC + VC Where: TC = Total cost (Total Cost) FC = Fixed cost (Fixed cost) VC = Variable cost (Variable cost). (2) Analysis of Income and Revenue of Monoculture and Polyculture Coffee Farming Businesses. Revenue Analysis According to Suratiyah (2006), in general the calculation of total revenue (Total Revenue/ TR) is the multiplication of the amount of production (Y) by the selling price (Py) and is expressed by the following formula: TR = Y. Py Where: TR = Total Revenue (Total revenue) Y = Production obtained Py = Price. Revenue Analysis According to Suratiyah (2006), revenue is the difference between revenue (TR) and total costs (TC) and is expressed by the formula: Pd = TR– TC Where: Pd = Revenue TR = Total revenue (Total revenue) TC = Total cost (Total Cost). (3) Feasibility Analysis. To test the level of feasibility, it is analyzed using the Return Cost Ratio analysis which is known as the comparison between revenue and costs. Systematically, this can be written as follows: a = R / CR = Py.Y C = FC + VC A = { (Py.Y) / (FC + VC)] Where: A = revenue / cost R = revenue C = Cost Py = Output price Y = Output FC = Fixed cost VC = Variable cost

- If R/C = 1, then the business is neither making a profit nor a loss.
- If R/C < 1, then the business is making a loss, because the business cannot produce the value of the costs used, in other words the business is not prospective.
- If R/C > 1, then the business makes a profit, in other words the business is prospective (Soekartawi, 1995).

(4) Analysis of Mean Difference Test (Compare Means) To explain the comparison of productivity and income levels of coffee farming for each cropping pattern, a Mean Difference Test (Compare Means) was used for both monoculture sample farmers and intercropping sample farmers. In this study, what will be compared is the productivity and income levels of monoculture farmers and farmers who practice intercropping. Because it comes from two different samples, the mean difference test used in this study is the Independent sample T-test. According to Sudjana (2002), the calculation of variance is done using the formula:

The average difference of the independent sample T-test method has the formula:

$$t = \frac{\overline{X1} - \overline{X2}}{\sqrt{\frac{s1^2}{n1} + \frac{s2^2}{n2}}}$$

Information:

X1 = average producti income level of monoculture farmers.

X2 = average productio $s1^2 = \frac{1}{n1-1}\sum (X1 - X1)^2$ ncome level of farmers in the agricultural sector intercropping.

$s2^2 = \frac{1}{n2-1}\sum (X2 - \overline{X2})^2$

s1² = variance of produc nd income level of monoculture farmers.

s2² = variance of production quantity, productivity and income level of farmers who carry out intercropping.

n1 and n2 = number of observations of the first and second data.

Kriteria pengujian, terima Ho jika :

$$-\frac{w1t1+w2t2}{w1+w2} < t' < \frac{w1t1+w2t2}{w1+w2}$$

Dengan:

$w1 = \frac{s1^2}{n1}$; $w2 = \frac{s2^2}{n2}$

$t1 = t(1 - 1/2\alpha), (n1 - 1)$

$t2 = t(1 - 1/2\alpha), (n2 - 1)$

H0: There is no significant difference in the two processes for producing productivity

H1: There is a significant difference in the two processes for generating productivity.

RESULTS AND DISCUSSION

The production of monoculture Arabica coffee cultivation in Tiga Panah and Barusjahe Districts is in the form of red beans (cherry red) and white beans, where the red beans are obtained directly from picking while the white beans are obtained from the process of peeling the coffee fruit skin (pulper) then fermented until the mucus attached to the coffee beans is lost. The average farmer in the research area sells in the form of white beans because the selling price is higher, which ranges from IDR 16,000 - IDR 17,000 / kg while the red beans range from IDR 5,000 - IDR 6,000 / kg, so the research was conducted on white bean Arabica coffee. Coffee fruit harvesting is done every 2 weeks, because the level of ripeness of the coffee fruit varies. Ripe fruit is red, if it is still green or yellow it is not yet categorized as ripe coffee fruit. Coffee bears fruit throughout the year but the most harvest is in the months of 9, 10, and 11.

Table 1. Average Production of Arabica Coffee Cultivation as Monoculture

	Land Area (Ha)	Production (kg)	Standard deviation
Per farmer	0.47 1	575.12 1,283.96	273.21
Per Ha	0.47 1	575.12 1,283.96	205.49

The average land area of Arabica coffee farmers who plant monoculture is 0.47 Ha with an average production of 575.12 kg/year with a standard deviation of 273.21. The lowest production is 200 kg/year with a land area of 0.16 Ha and the highest production is 1,328 kg/year with a land area of 1.00 Ha. Low production is due to narrow land, when compared to other samples with the same land area of 0.16 Ha, then 200 kg/year is considered

low, this is because the age of the plant is just producing so that the coffee bean yield is still low. While the average production of Arabica Coffee per Ha is 1,283.96 kg/ha/year with a standard deviation of 205.49.

Table 2. Average Production of Arabica Coffee Cultivation by Intercropping

	Land Area (Ha)	Arabica Coffee (kg)	Cabbage (kg)	White Mustard (kg)	Standard deviation
Per farmer	0.47 1	721.54	7,580	959	3,463.10
Per Ha	0.47 1	1,613.17	18,545.24	1,703.66	5,999.83

The average area of Arabica coffee farmers' land in intercropping is 0.49 Ha with an average production of Arabica coffee cultivation of 721.54 kg/year with the lowest production of 240 kg/year on 0.12 Ha of land and the highest production of 1,530 kg/year on 1.00 Ha of land with a standard deviation of 3,463.1. The average production of 9 per Ha of Arabica coffee cultivation in intercropping is 1,569.25 kg/ha/year while for each intercropping production produces 18,545.24 kg/ha/year of cabbage and 1703.66 kg/ha/year of Chinese cabbage with a standard deviation of 5,999.83. The higher the productivity, the better the land's utilization, resulting in higher production. To increase productivity, many farmers in Tiga Panah and Barusjahe Districts are intercropping their land.

Table 3. Average Productivity of Arabica Coffee Cultivation Planted as Monoculture and Intercropping

	Land Area (Ha)	Productivity (kg/Ha/year)	Standard deviation
Monoculture	1	1,283.96	205.49
Intercropping	1	1,613.17	357.02

From table 3, the average productivity of Arabica coffee cultivation planted in monoculture is 79.6% of the average productivity of Arabica coffee cultivation planted in intercropping. The difference in productivity of Arabica coffee cultivated in intercropping is higher because the coffee fruit planted in intercropping is larger and more numerous than that planted in monoculture so that the quality of the coffee fruit in intercropping is better. To calculate costs and income in farming, three kinds of approaches can be used, namely the nominal approach, the future value approach, and the present value approach (Suratiyah, 2008). In this case, the nominal approach is used without taking into account the time value of money but what is used is the prevailing price, so that the amount of expenditure and the amount of income can be directly calculated in a production period. The formula for calculating nominal income is: Income = Income - Total Cost (Suratiyah, 2008).

Table 4. Average Income from Arabica Coffee Cultivation in Monoculture and Intercropping per hectare

	Income (Rp/year)	**Production Cost (Rp/year)**	**Income (Rp/year)**
Per Farmer			
Coffee (Monoculture)	9,549,415	2,836,654	6,712,760
Coffee (Intercropping)	11,897,585.37	2,023,708	9,873,877
Per Ha			
Coffee (Monoculture)	21,325,941.06	5,981,167	15,344,774
Coffee (Intercropping)	26,764,099.60	4,030,546	22,733,553

From table 4, the average income per hectare of monoculture Arabica coffee cultivation is 67.49% of the income from intercropping Arabica coffee cultivation, so that the income from intercropping Arabica coffee farming is clearly higher. The average production cost for monoculture and intercropping differs by Rp 1,950,621 per year. Intercropping Arabica coffee has lower production costs because more fertilizer is applied to the intercropped plants than to the Arabica coffee plants themselves. Monoculture Arabica coffee plants require more fertilizer because it is applied directly to the coffee plants. Meanwhile, fertilizer applied to intercropping plants can also be used for intercropping Arabica coffee plants. Fertilizer from intercropping plants is more fertile, resulting in better quality coffee beans when intercropped.

Table 5. Average Income from Arabica Coffee Cultivation by Intercropping and Planting Intercropping

	Income (Rp/year)	**Production Cost (Rp/year)**	**Income (Rp/year)**
Per Farmer			
Coffee (Monoculture)	10,786,564	2,023,708	8,873,877
Coffee (Intercropping)	20,342,575	2,107,784	18,345,801
Per Ha			
Coffee (Monoculture)	25,653,099	4,704,575	21,059,524
Coffee (Intercropping)	43,860,725	4,699,034	39,271,691

Table 5 shows that the average income from intercropping Arabica coffee cultivation is 54.78% of the average income from the intercropped crop itself. Based on income, it appears that the intercropped crop is the primary crop, as it provides a higher income. However, given the unique nature of Arabica coffee, which can only grow at certain altitudes, Arabica coffee farming in the research area should be maintained, even though growing seasonal crops such as intercropping provides higher incomes. Furthermore, intercropping Arabica coffee offers the advantage of higher-quality coffee cherries and a higher weekly income compared to intercropping. To strengthen the results of the data obtained, several calculations were performed to demonstrate the comparative productivity and income levels between monoculture and intercropping Arabica coffee farms. If the two standard deviations are not equal but both populations are normally distributed, there is currently no precise statistic that can be used. A satisfactory approach is to use the t2 statistic (Sudjana, 2002).

1. Productivity Level Comparison

According to the testing criteria, it is obtained: -2.02 >9.68 <2.02 or does not comply with the existing testing criteria, so reject Ho and accept H1.

Ho: there is no real difference in the two processes for producing productivity

H1: There is a significant difference in the two processes for producing productivity

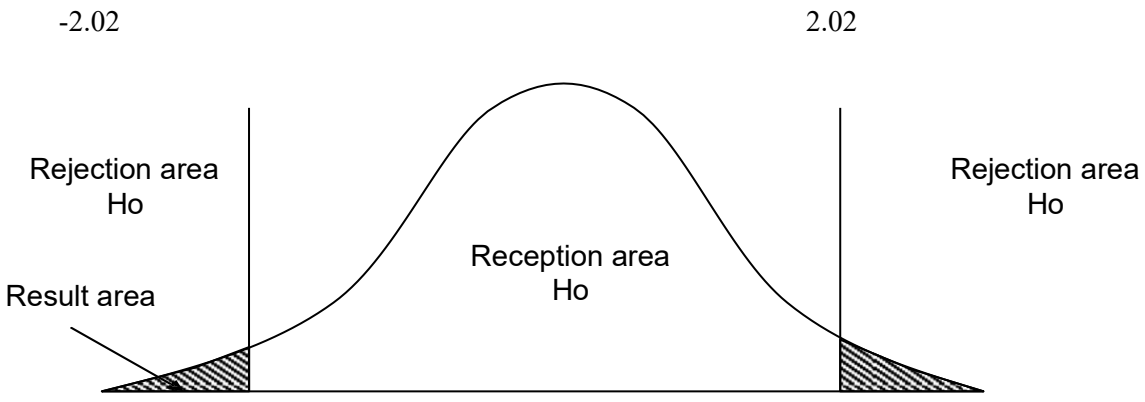


Figure 1. Normal curve of Arabica coffee cultivation productivity comparison

This means that in producing production, the two processes, namely monoculture and intercropping, produce productivity with different average results or the capacity to produce production is significantly different.

2. Income Comparison

According to the testing criteria, it is obtained: -2.02 > -16.8 < 2.02 or does not comply with the existing testing criteria, so reject Ho and accept H1.

Ho : there is no real difference in the two processes to produce productivity

H1 : there is a significant difference in the two processes for generating productivity

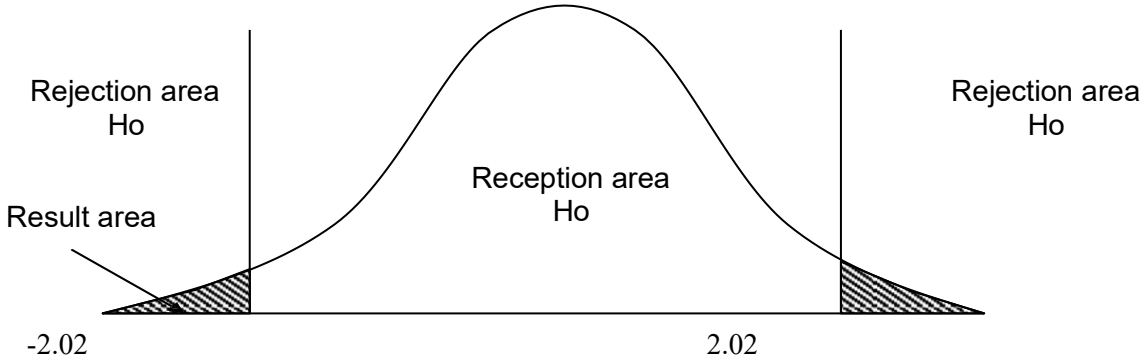


Figure 2. Normal curve of Arabica coffee cultivation income comparison

This means that in producing both processes, namely monoculture and intercropping, the income generated is different on average or the power to produce income is significantly different. The calculations show that intercropping farming produces significantly different productivity and income compared to monoculture farming. All comparative productivity and income level calculations yield the same result, rejecting Ho and accepting H1. The problems faced by farmers in cultivating Arabica coffee as a monoculture in the research area include: Influence of climate and environment, business scale, price information and low knowledge about intercropping cultivation. The problems faced by farmers in intercropping Arabica coffee cultivation in the research area include: Climate and environmental influences, price information, intensive care, labor and business scale.

CONCLUSION

The average productivity of monocultured Arabica coffee cultivation is 79.6% of the average productivity of intercropped Arabica coffee cultivation. The average income per hectare of monocultured Arabica coffee cultivation is 67.49% of the income of intercropped Arabica coffee cultivation. Meanwhile, the average income of intercropped Arabica coffee cultivation is 54.78% of the average income of the intercropping itself. The results for each comparison between productivity and income levels between monoculture and intercropping Arabica Coffee farming are rejecting Ho and accepting H1, meaning that there is a real difference for each comparison between productivity levels and income levels of monoculture and intercropping Arabica Coffee farming. The problems faced by farmers in cultivating Arabica coffee in monoculture and intercropping in the research area include: the influence of climate and environment, business scale, price information, low knowledge about intercropping cultivation, intensive care, and labor.

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