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Farmers Characteristics in Bioindustrial Agriculture Based on the Cattle-Oil Palm Integration in Jambi Province, Indonesia

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Abstract—This study aimed to determine the characteristics of farmers and to analyze the factors influencing the application of bioindustrial agriculture technology based on the cattle-oil palm integration. The study was conducted in Jambi Province, Indonesia with 225 respondents. Respondents were selected using multistage cluster random sampling. The analysis of the effect of characteristics on the application of bioindustrial agriculture technology was carried out by multiple regression analysis. Results showed that the farmers in the study area was relatively old with low education level but their income and experience were high categorize. The land size of oil palm was in the medium category, the age of oil palm was classified as old, and the number of cattle was classified as moderate. The level of application of bioindustrial agriculture technology based on the cattle-oil palm integration was in the medium category. The characteristics of farmers simultaneously had a very significant effect on the level of application of bioindustrial agriculture technology. The characteristics of farmers that have a significant effect on the application of bioindustrial agriculture technology were income, experience, land size of oil palm and number of cattle. The development of bioindustrial agriculture needs to be carried out continuously by disseminating bioindustrial agriculture technology by giving attention to the characteristics of farmers, capital support, facilities and infrastructures.

Keywords— Adoption; Bioindustry; Innovation; Sustainable Agriculture; Technology Application.

I. INTRODUCTION

The efforts to meet food needs become the important issue. It is due to the rapid growth of human and followed by the decrease of agriculture land. On the other hand, agriculture is faced with environmentally development issue, in order to maintain sustainable development. One form of sustainable agricultural development is bioindustrial agriculture. Bioindustrial agriculture is agriculture that minimizes waste, and utilizes waste for recycling as input from bioindustrial agriculture. Bioindustrial agriculture based on the integration of crops and livestock is also a diversification of farming that can be an alternative additional income for small farmers as well as a good risk management effort [1, 2]. Indonesia has monoculture cultivation system. The weakness of this cultivation is the farmers will not get income if farming fails, a way to overcome this is with an integrated farming system in the form of crop-livestock integration [3]. The integration of crops and livestock will ensure the sustainability of agriculture [4]. The most potential integration agriculture for Indonesia is the integration of cattle and oil palm plantations.

Jambi is one of the provinces in Indonesia that has a large area of oil palm plantations. The oil palm plantations are dominated by small-scale plantations. Likewise the cattle, most of which are small-scale cattle farms. Therefore, bioindustrial agriculture based on the integration of cattle with oil palm plantations, must emphasize the empowerment of small farmers. Bioindustrial agriculture is agriculture that requires technology, because it requires the adoption of technological innovations by farmers. Devendra [5] stated that many crop-livestock integration technologies are available, but they are not adopted. The

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successful application of a technology is influenced by many factors. One of the most important factors is the characteristics of farmers, both individual characteristics and agribusinesses characteristics. According to [6], farmer characteristics become a factor in policy considerations for beef cattle business development. The adoption of agricultural technology depends on the characteristics of the farmers, the characteristics of the farm, the characteristics of technological innovation and the characteristics of the institution [7, 8, 9, 10]

This study aimed to determine and to analyze the characteristics of farmers in bioindustrial agriculture based on the cattle-oil palm integration, as well as to see the effect of farmer characteristics on the successful application of bioindustrial agriculture technology in Jambi Province, Indonesia.

II. MATERIALS AND METHODS

The research method is quantitative methods. A descriptive analysis was used to strengthen the qualitative data. The study was conducted in Jambi Province from August 2020 to February 2021. The sampling method used the multistage cluster random sampling method. The research location was selected based on the farmers who carry out cattle-oil palm plantation based on bioindustrial farming and the geographical conditions of the area. The research was conducted in three sub-districts in three districts, namely Tebing Tinggi District, Tanjung Jabung Barat District, Sungai Bahar District, Muaro Jambi District and Renah Pamenang District, Merangin District. The number of farmers as respondents was 225 people out of 445 farmer populations who carried out the integration pattern in the study area.

Data collection techniques was carried out through interview with respondents and direct observation. To strengthen the analysis, interview was conducted with field extension officers and related agencies. The data collected consisted of farmer characteristics, the performance of farming and the application of bioindustrial agriculture technology.

Data analysis was carried out by descriptive analysis to explain the farmer characteristics. The success rate of technology implementation was measured using a five scale system (very low, low, medium high and very high). The success rate of technology application measured consisted of cattle grazing in oil palm plantations, planting forage between oil palm plants, utilization of palm leaves and midribs for animal feed, utilization of palm oil mill waste for animal feed, utilization of livestock manure for biogas, and utilization of feces/ livestock urine and palm oil waste for composting. Validity and reliability tests were conducted to determine the reliability of the research instrument. Multiple Regression Analysis was used to analyze the effect of characteristics on the success rate of technology application using SPSS tools.

III. RESULTS AND DISCUSSION

3.1. Farmer Characteristics

The personal characteristics of farmer are related to the background of farmers that may influence their efforts in carrying out bioindustrial agriculture. The personal characteristics include age, formal education, income, and experience in practicing bioindustrial agriculture based on cattle-oil palm integration. The personal characteristics of the farmer are as listed in Table 1.

TABLE 1 PERSONAL CHARACTERISTICS OF FARMER

Characteristics	Interval	ategory	Number of Respondents	Percentage
Age (years)	<30	Very Young	6	2.67
	30 - 39	Young	31	13.78
	40 - 49	Moderate	84	37.33
	50 - 59	Old	73	32.44
	>60	Very Old	31	13.78
Age average				48.2 year

Formal education	Not Elementary	Very low	9	4.00
	Elementary school	low	107	47.56
	Yunior high school	Moderate	45	20.00
	Senior high school	high	59	26.22
	University/Academy	Very high	5	2.22
Income (IDR)	<1,315,081,-	Very low	4	1.78
	1,315,081,--2,630,162,-	low	17	7.56
	2,630,162,--5,260,324,-	Moderate	99	44.00
	5,260,324,--10,520,648,-	high	74	32.89
	>10,520,648,-	Very high	31	13.78
Income average				IDR 5.405.930,-
Length of bioindustrial agriculture experience (years)	≤3	Very low	15	6.67
	4 - 6	low	30	13.33
	7 - 9	Moderate	16	7.11
	10 - 12	high	95	42.22
	>12	Very high	69	30.67
Experience average				11.9 year

The farmers were dominated with age interval between 40-59 years (69.77 %). The average of farmers age was 48 years and 2 months. The data showed that the farmers were classified as medium to old age. It means that more farmers were at an older age than younger farmers. It is also supported by data from farmers aged over 60 years were more than farmers aged under 30 years. In fact, Bioindustrial agriculture has not been able to attract the young people interest. It should be a concern because of the importance of the farmers regeneration. The farmers regeneration and the involvement of the younger generation in agriculture is very important because it is related to agribusiness sustainability [11, 12].

Formal education is taken by farmers in the formal education system in Indonesia, from Elementary school to University/Academy. Most of the farmers finished elementary school (47.56%). This fact showed that the level of formal education of farmers is in the low category. It is reinforced by data that there are more farmers who did not complete elementary school than those who graduated from university/academy. The research of [6] showed that generally the characteristics of beef cattle farmers in the districts of Timor Tengah Utara and Belu were in the low category.

Farmer income is from bioindustral agriculture, namely from oil palm plantations and cattle. The income categorization is based on the Jambi Province minimum wage that is IDR 2,630,162,-. Farmers who were under wage income were categorized as low income, while those who earn more than twice of the wage were categorized as high. Based on this categorization, the income of bioindustrial agriculture farmers in the study area was dominantly medium and high (76.89%). The average income of respondents was IDR 5,405,930, - per month, including the high category. Dib et al [13], states that households in oil palm plantation areas have better incomes than farmers of rubber and other crops.

Farmers experience is the time of farmers have carried out cattle-oil palm integration. The data showed that the experience of farmers was in very high categories (72.89%). This showed that the integration of cattle and oil palm plantations had carried out by farmers for a long time.

3.2. Farm Characteristics

Farm characteristics of farmer is the characteristics of the agriculture in cultivating oil palm plantations and raising cattle that is reflected in the land size of oil palm plantations, the age of oil palm and the number of cattle owned. The characteristics of the farming business are listed in Table 2.

TABLE 2 FARM CHARACTERISTICS

Farm Characteristics	Interval	Category	Number of Respondents	Percentage
Land size of oil palm plantation (Ha)	≤1	Very small	30	13.33
	>1 - <3	Small	112	49.78
	3 - <5	Medium	49	21.78
	5 - <7	Large	25	11.11
	≥7	Very Large	9	4.00
Land size average				2.92 Ha
Oil palm age (years)	≤5	Very young	1	0.44
	>5 - 10	Young	5	2.22
	>10 - 15	Medium	29	12.89
	>15 - 20	Old	78	34.67
	>20	Very old	112	49.78
Oil palm age average				20.8 year
The number of cattle (Animal Unit/AU)	≤ 1	Least	5	2.22
	>1 - <3	Little	66	29.33
	≥3 - <5	Medium	94	41.78
	≥5 - <7	Plenty	38	16.89
	≥7	Huge	22	9.78
The number of cattle average				4.20 AU

Farmers in the study area were smallholders with an average land ownership of oil palm plantations of 2.92 Ha with an ownership interval of 1-12 Ha. These oil palm plantations were generally obtained from partnerships with companies. The oil palm plantation area was considered adequate by the farmers.

Almost half of the oil palms (49.78%) were more than 20 years old. It is in very old categorize. Although oil palm plantations varies from 5 years-28 years, the average age was very old (20.8 years). Currently, some farmers had started replanting their oil palm plantations. Business variations at the level of small farmers, such as bioindustrial agriculture can support the economy of farmer families.

The number of respondent cattle varied between 1 -16.7 Animal Unit/AU with an average number of cattle 4.20 AU per farmer. The percentage of dominant ownership was 3-5 AU (41.78%) categorized as moderate. Generally, cattle farming is a side business, not the main business of farmers in rural Indonesia. According to [14] Cattle ownership of farmer is relatively small, which is less than 3 heads.

3.3. Application of Bioindustrial Agriculture Technology

Bioindustrial agriculture technology in the study area is based on the integration between cattle farm and oil palm plantations. This integration pattern activity consists of several forms, namely direct integration with cattle grazing on oil palm plantations, planting forage in oil palm plantations area, utilizing palm leaves and midribs for feed, making compost from cattle manure and oil palm waste, and utilizing livestock manure for biogas. Not all technologies can be applied properly by farmers. Fadeyi et al. [15] stated that the level of technology adoption is influenced by various complex and dynamic factors interaction.

Most of the farmers in the study area have oil palm plantations. Total area in the 3 sub-districts is 70,602 ha, with 33,976 ha (48.12%) of oil palm plantations. The total population of cattle in this area is 3,842 heads. The ratio between the number of cattle and the area of oil palm plantations in the study area is 0.11, or 11 cattle per 100 ha of oil palm plantations. It showed that although bioindustrial agriculture has been implemented, it has not been able to increase the cattle population in the study area. Refer to [16], the area suitable for raising cattle is about 60% from the total area of oil palm plantations. Based on this opinion, the area of oil palm plantations in the study area can be integrated with cattle should be 20,385 hectares. If the direct integration pattern is applied, then the oil palm plantation can accommodate one cow per hectare, then the study area will be able to accommodate 20,385 cattles, or the remaining capacity of 16,543 cattles. If the integration pattern is not applied directly, it will be able to accommodate more cattle.

The success of technological innovation in society can be seen from the level of technology application. This success can be in the form of increasing farmer knowledge and the application at the farmer level. The application of bioindustrial agriculture technology based on the cattle-oil palm integration by farmers in the study area was very high (3.11%) category, high (33.33%), moderate (48.00%), and low (15.56 %). This figure showed that most of the farmers were in the moderate category in the application of bioindustrial agriculture. This also indicates that technology dissemination and increasing interest and motivation in the application of bioindustrial agriculture based on cattle-oil palm integration are still needed in the study area. Disseminated technology must meet the criteria for innovation characteristics that are acceptable to farmers and their environment. According to [17], the characteristics of innovation greatly influence the farmers decision to accept innovations in crop-livestock integration technology.

3.4. The Influence of Farmer Characteristics on the Bioindustrial Agriculture Technology Application

The influence of farmer characteristics on bioindustrial agriculture technology based on the cattle-oil palm integration was measured using multiple linear regression analysis. The results of the analysis obtained the following model:

$$Y = 16{,}291 + 0{,}027\ X1 - 0{,}054\ X2 + 0{,}301\ X3 + 0{,}084\ X4 - 0{,}811\ X5 - 0{,}096\ X6 + 0{,}478\ X7$$

Y = Level of bioindustrial agriculture technology application

X1 = Farmer age

X2 = Farmer formal education

X3 = Farmer Income

X4 = Experience of farmers in performing bioindustrial farming

X5 = Land size of oil palm plantation

X6 = Age of oil palm plantation

X7 = Number of cattle

The results of multiple regression analysis showed the calculated F value of 13.721 with a significance level of <0.001. It indicates that the model of farmer characteristics on the application of bioindustrial agriculture technology can be used with a very significant level of influence ($P<0.01$). However, the coefficient of determination (R^2) is 0.307. This result showed that the

influence of farmer characteristics on the application of bioindustrial agriculture technology by farmers can be explained simultaneously by 30.70%. This indicated that there were many variables beside farmers characteristics that influence farmers in the bioindustrial agriculture technology application based on the cettle-oil palm integration. These variables can be in the form of farmer family characteristics, demographic background, geographical conditions, natural environment, farmer group activities, communication and extension, infrastructure, and support from the government. According to [18] the level of risk communication at the farmer level is influenced by socioeconomic conditions, farmer characteristics, access to agricultural information, and institutional support. Munguia et al [19] found an interaction between decision making and attitudes towards technology with external influences and characteristics of adopters. Adoption rates are influenced by extension workers, culture and farmer background [20].

Based on the model above, the increase of bioindustrial technology application was 1 basis point, it is necessary to increase income by IDR 301,000.-, increase farmer experience by 0.08 years, and increase cattle ownership by 0.478 animal unit. The influence of each farmer characteristics on the application of bioindustrial technology based on cattle integration with oil palm is as shown in table 3.

TABLE 3 RESULTS OF THE ANALYSIS OF THE INFLUENCE OF FARMER CHARACTERISTICS ON THE APLICATION OF BIOINDUSTRIAL AGRICULTURE TECHNOLOGY

Model	**Unstandardized Coeffecients**		**Standardized Coeffecients**	**t**	**Sig.**
	B	**Std error**	**Beta**		
Constant	16.291	2.488	-	6.547	<0.001
Age (X1)	0.027	0.032	0.062	0.852	0.395
Education (X2)	-0.054	0.314	-0.012	-0.172	0.863
Income (X3)	0.301	0.084	0.281	3.595	<0.001**
Experience (X4)	0.084	0.038	0.139	2.248	0.026*
Land size of oil palm(X5)	-0.811	0.168	-0.391	-4.830	<0.001**
Age of oil palm (X6)	-0.096	0.073	-0.087	-1.307	0.193
Number of cattle (X7)	0.478	0.097	0.361	4.917	<0.001**

* = significant (P<0.05)

** = very significant (P<0.01)

Farmer characteristics that significantly affect the application level of bioindustrial technology based on cattle-oil palm integration were personal characteristics in the form of income (X3) and farmer experience (X4) in carrying out bioindustrial agriculture, as well as the characteristics of agribusiness in the form of land size of oil palm plantation (X5) and the number of cattle (X7). The success of technology adoption is strongly influenced by the scale of farming and income [21]. Farming scale and experience of farmers have an effect on farmers perceptions [22]. While the factors of age (X1), formal education (X2) and age of oil palm plantations (X6) have no significant effect. Age and education of farmers are not obstacles in develop of farming business [23]

Farmer income had very significant effect (P<0.01) on the application of bioindustrial agriculture with a positive correlation, it means that the higher the income, the higher the application of bioindustrial agriculture technology. This is because the access to capital resource, infrastructure and information technology will be easier to do with high income. Income has a very significant effect on farmer satisfaction in integrating cattle and oil palm [24]. Factors that significantly affect the intensity of technology adoption are mentoring programs and farmer income [25].

The application of bioindustrial agriculture technology was significantly affected (P<0.05) by the length of time farmers had to integrate cattle with oil palm, with a positive correlation. It is clear that the longer farmers apply the integration technology

of cattle and oil palm, the easier in knowledge and mastery of bioindustrial agriculture technology. The experience influences farmers to raise cattle in oil palm plantation areas [26].

Land size of Oil palm plantation had a very significant effect ($P<0.01$) on the application of bioindustrial agriculture technology, but had a negative correlation. This may be due to the fact that farmers who have less land are more motivated to increase their income and have more time to apply bioindustrial agriculture technology. The number of cattle owned by farmers had a very significant effect ($P<0.01$) on the application of bioindustrial agriculture technology, with a positive correlation. It means that the more cattle they have, the more motivated farmers will be to do the bioindustrial farming. It is understandable because bioindustrial agriculture is agriculture that utilizes agricultural waste, thus farmers need inputs for bioindustrial agriculture derived from livestock manure, such as for the use of biogas and composting. The more cattle a farmer has, the more inputs that can be utilized. The scale of farming in terms of land size and number of livestock greatly determines the willingness of farmers to adopt technology [27]. Improving the welfare of farmers and strengthening food security while maintaining environmental sustainability can be done by developing an integrated system of plants and livestock [28].

Based on the results, the policy implication that can be recommended is that the characteristics of farmers had a very significant effect on the application of bioindustrial agriculture technology based on the of cattle-oil palm integration. However, there are many factors that influence farmers in applying bioindustrial agriculture technology. The development of bioindustrial agriculture based on the integration of cattle and oil palm needs to pay attention to the characteristics of farmers, including income, experience, land size of oil palm plantation and number of cattle. It can be done by continuing to disseminate bioindustrial agriculture technology and support capital, facilities and infrastructures that can support the development of bioindustrial agriculture. In addition, efforts are needed to attract the interest of the younger generation to be involved in bioindustrial agriculture. The factors that have a significant and positive effect on participatory communication are individual characteristics and institutional support [29]. Farmer characteristic factors must be given adequate consideration in extension, because they affect technology adoption [30]. Bioindustrial agriculture will be able to increase the empowerment of farmers and will encourage sustainable agriculture in an effort to preserve the environment. Sustainable management and development of cattle-oil palm integration will be able to improve farmers welfare [31]

IV. Conclusion

The farmers characteristics in bioindustrial agriculture based on the cattle-oil palm integration were relatively old in age, low level of formal education, high income, high experience, medium category on size land of oil palm, the age of oil palm was classified as old, and the number of cattle was classified as moderate.. The application level of bioindustrial agriculture technology based on the cattle-oil palm integration was in the medium category. The characteristics of farmers simultaneously had very significant effect on the application level of bioindustrial agriculture technology. Partially, the characteristics of farmers that have a significant effect on the application of bioindustrial agriculture technology were income, experience, land size of oil palm and number of cattle. The development of bioindustrial agriculture needs to be done continuously by disseminating bioindustrial agriculture technology by giving attention to the characteristics of farmers, regeneration of farmer, as well as capital support, facilities and infrastructures that support the development of bioindustrial agriculture.

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