Factors affecting farmers’ decision to use organic fertilizers on Robusta coffee plantation: A case study in Tanggamus, Lampung

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Abstract. The dependency on agri-chemical inputs, such as fertilizers and pesticides, tends to increase among small-scale farmers in developing countries. On the other hand, demand for organic products, including coffee, continuously increases due to the rising concern of the consumers for sustainable products and a healthy lifestyle without chemical residues. This study aims to understand the determinant factors that affect small-scale farmers in using organic fertilizers. The research was conducted in Tanggamus Regency from June – August 2019 using a survey method. Respondents were determined using a simple random sampling method. Data were analyzed using descriptive statistics and a linear regression model. The results showed that the use of organic fertilizers is still limited and farmers tend to use chemical fertilizers to maintain their coffee plants. The dose of inorganic fertilizer and ownership of the number of coffee trees have a negative effect on the application of organic fertilizer. While the experience of farmers in coffee farming and the age of coffee plants have a positive effect on the dose of organic fertilizer applied.

Keywords: Robusta coffee, organic fertilizer, farmer’s experience, Tanggamus

1. Introduction

The changes in agricultural environmental conditions tend to increase the dependency of farmers in developing countries on chemical inputs such as fertilizers and pesticides [1-4]. Even though the intensification practices potentially increase farm productivity as a response to the diminishing ecosystem supports, inappropriate application of chemical inputs can cause negative externalities on the environment. For example, increasing the use of chemical fertilizers can cause an imbalance of soil nutrients and contribute to serious harm to soil, air, and water pollutions [5, 6].

In order to reduce the negative impact of the chemical fertilizer application, organic fertilizer is often considered as an alternative nutrient source for the plant [7]. Many studies have shown that organic fertilizer can substitute chemical fertilizer in order to increase the farm yield [8, 9]. In the long term, organic fertilizer can also improve soil fertility and microorganism population [10].

While organic fertilizer is acknowledged as a vital component of sustainable agriculture, the increasing consumers’ concern for healthy sustainable products strengthens the importance of the application of organic fertilizer, especially for food crops, including coffee. Demand for sustainable coffee products shows an increasing trend with the premium price [11]. In order to fulfill this demand,
certified sustainable coffee production also shows positive growth. Based on 2008 – 2016 data, certified coffee area by five leading coffee certification labels, i.e., The Common Code for the Coffee Community (4C), Fairtrade, Organic, Rainforest Alliance, and Utz, increased by almost 80 percent [12].

One of the important components in organic/sustainable coffee cultivation is the application of organic fertilizers. Coffee plants require high levels of organic matter in the soil because organic matter functions as a water reservoir, nutrients, and improvement of physical soil characteristics. On the other hand, coffee plants are not resistant to water shortages as the lack of water for the coffee plant can cause physiological problems and decrease production dramatically. Considering the importance of organic fertilizer for coffee production on the one hand, and increasing consumer demands for organic products, on the other hand, the application of organic fertilizer by farmers should be increasing, but this has not worked as it should. This study aims to determine what factors influence farmers’ decision in using organic fertilizers on their coffee plantations.

2. Literature review: Coffee farming characteristics in Lampung Province

The dynamic of Indonesian coffee agribusiness is directly influenced by the situation of the world coffee market. In the last few years (2016-2019), there has been an oversupply trend of coffee in the world, which is indicated by the amount of production that exceeds consumption, resulting in a decline in prices [13]. On the other hand, as one of the largest Robusta coffee exporters, the competitiveness of Indonesia is still lower than Vietnam [14].

Lampung, as one of the leading Robusta coffee-producing areas in Indonesia, often represents the situation of coffee farming. This province contributed 20.85 percent of the total Robusta coffee production or 14.63 percent of the total national coffee production in 2018 [15]. As a major producing area, Robusta coffee produced from this area has a good reputation and is in demand by Indonesian consumers who prefer this type of coffee because of its thick characteristics with high caffeine content. In addition, the high production of coffee in this area and surrounding areas, particularly South Sumatra and Bengkulu, has made Lampung Province as the main export gateway for Indonesian coffee with a share of more than 70 percent of Indonesia's total coffee exports [16].

Coffee farming in Lampung is dominated by small-scale farmers with an area of less than 1 ha [17]. The coffee plantation is characterized by low-input application which is followed by low productivity [18]. Hasibuan, Listyati and Sudjarmoko [19] also identify that the adoption of certified improved variety and other technology recommendations was relatively low. In addition, coffee farmers in this province have low institutional support, limited information access, and weak farmers’ organizations. These conditions contribute to relatively low coffee productivity and a weak bargaining position along the coffee supply chain [18, 20].

As one of the largest coffee producers in Indonesia, Lampung has the potential to fill market opportunities, both domestic and international markets, which tend to move to consume sustainable coffee products. The increasing market demand for organic products at premium prices should be able to attract farmers to apply organic coffee cultivation systems. Hence, the increase in organic coffee production is expected to increase income or profits for farmers. Related to the decline in coffee prices, sustainable coffee management such as organic cultivation is often considered as one of the important instruments that can be applied by farmers [21, 22]. Fertilization using organic fertilizers, which should be easily obtained in the field, is also not implemented properly. Therefore, it is necessary to know the factors that influence farmers in using organic fertilizers on their coffee plants, so that farmers can meet the nutrient needs of coffee plants and increase organic coffee productivity.

3. Methodology

3.1. Study sites

The study sites were determined intentionally, namely in Sumber Mulya and Tegal Binagun Villages, Sumberejo Subdistrict, Tanggamus Regency, which are coffee production centers in Lampung. Coffee plantations were owned by smallholder farmers. The research was conducted in April-June 2019.
3.2. Data collection
Coffee farmers who were used as samples in this study were determined by using a simple random sampling technique in village levels. The number of selected sample farmers were 24 households from the two selected villages. Meanwhile, data collection was carried out through surveys using a structured questionnaire. In order to obtained deeper information about coffee farming, the research team also conducted direct interviews with key informants, such as farmers group leaders, extension workers, and local government.

3.3. Data analysis
The relationship between explanatory variables and the application of organic fertilizers by smallholder farmers in the study sites, we estimated using a multiple linear regression model which estimated using the Ordinary Least Square (OLS) method and STATA 16 Software [23]. The specification of the model used in this study is as follows:

\[ \text{Org}_i = \beta_0 + \beta_1 \text{Anorg}_i + \beta_2 \text{UP}_i + \beta_3 \text{Pglmn}_i + \beta_4 \text{Plthn}_i + \beta_5 \text{TK}_i + \beta_6 \text{Modal}_i + \beta_7 \text{Tan}_i + \beta_8 \text{UT}_i + \epsilon_i \]

where \( \text{Org}_i \) represents application of organic fertilizer by respondent \( i \) (gr/tree), \( \text{Anorg}_i \) is the application of chemical fertilizer by respondent \( i \) (gr/tree), \( \text{UP}_i \) is the age of the respondent (year), \( \text{Pglmn}_i \) is farmer experience in coffee farming (year), \( \text{Plthn}_i \) dummy of farmers involvement in coffee training, \( \text{TK}_i \) is farm labor, \( \text{Modal}_i \) is dummy of financial capital assistance, \( \text{Tan}_i \) is number of coffee trees ownership and \( \text{UT}_i \) is age of the coffee trees (year). While \( \epsilon_i \) denotes the error terms and \( \beta_k \) (\( k=0,\ldots,K \)) are the coefficients to be estimated. This study expects that chemical fertilizer and the number of coffee trees have negative association with the use of organic fertilizer use. While, age, experience, training, farm labor, tree age and capital were hypothesized to influence the use of organic fertilizer positively [7].

4. Results and discussion
4.1. Respondent characteristics
Farmer characteristics are an important component in technology adoption, including the use of organic fertilizers. Previous studies have shown that the variables such as age and experience of farmers and farming assets such as land and tree ownership are important factors in the application of organic matters in agriculture [8, 24].

4.1.1. Farmers’ age. The average age of the respondents was relatively high, namely 42.46 years. Based on the distribution, 33.33 percent of the age of coffee farmers ranged from 53-58 years, followed by the age of 47-52 years (29.17 percent) (Table 1). This age range also corresponds to the general range of coffee farmers in Indonesia. According to the results of a national household survey in 2014, the majority of coffee farmer’s age (68.5 percent) was under 54 years old [25]. This figure also shows that most coffee farmers are in productive age. However, the distribution of farmers’ age implies that the interest of younger farmers with the age less than 40 years is relatively low. This finding is also strengthening the national concern of aging farmers. As the implication, it could contribute to a lower ability for technology adoption.

### Table 1. The distribution of farmers age.

| No. | Age ranges (years) | No. of respondents | Percentage (%) |
|-----|-------------------|--------------------|----------------|
| 1.  | 36-41             | 6                  | 25.00          |
| 2.  | 42-46             | 3                  | 12.50          |
| 3.  | 47-52             | 7                  | 29.17          |
| 4.  | 53-58             | 8                  | 33.33          |
| Total |                   | 24                 | 100.00         |
4.1.2. **Experience.** Most of the farmers (83.33%) had more than 11 years of experience in coffee farming, and 50% of them have more than 17 years. Meanwhile, the proportion of farmers who have experience under 5 years is relatively small (4.17%) (Table 2). This data shows that coffee farmers in Tanggamus have relatively sufficient experience in cultivating coffee.

| Experience (years) | No. of farmers | Percentage (%) |
|-------------------|---------------|----------------|
| <5                | 1             | 4.17           |
| 6-10              | 3             | 12.50          |
| 11-15             | 8             | 33.33          |
| 16-20             | 7             | 29.17          |
| 21-25             | 5             | 20.83          |
| **Total**         | **24**        | **100**        |

4.1.3. **Coffee tree age.** Productive plantations with an average tree age of more than 21 years old reached 66.66% (Table 3). Based on Byrareddy, Kouadio, Mushtaq and Stone [17]’s research in 2008 in the main coffee producing regions of Indonesia (Lampung, South Sumatra, and Bengkulu), the composition of coffee plantations with the age of more than 20 years was only 20%. Thus, the high composition of coffee plants aged more than 21 years in this study indicates that the rejuvenation process carried out by farmers was not going well. On the other hand, at this age, plant productivity begins to decline and is relatively lower than its potential yield. The peak of coffee plant production is reached at the age of 5-15 years, then it will decrease [26]. Hence, it can be explained that as many as 50% of plants that are more than 21 years old have entered the phase of old plants that require rejuvenation. Rejuvenation is an aspect of cultivation that contributes to the achievement of coffee plant productivity, in addition to land preparation and planting techniques. However, rejuvenation activities are relatively costly where most of the farmers probably do not have resources for replanting.

| Coffee tree age (year) | Percentage (%) |
|------------------------|----------------|
| <15                    | 16.67          |
| 16-20                  | 16.67          |
| 21-30                  | 45.83          |
| 31-40                  | 16.67          |
| >40                    | 4.16           |
| **Total**              | **100.00**     |

4.1.4. **Coffee productivity.** The study area has the potential for coffee development based on agroclimatic and land suitability analysis, which is in the category of suitability class S1 or appropriate [27]. However, in order to achieve the potential yield, coffee plantation needs to follow the good agricultural practices. Based on our survey, only 50 percent of respondents have a productivity of more than 800 kg/ha/year, and the remaining 50 per cents only have production between 300–800 kg/year/year (Table 4). This finding implies that the productivity of smallholder farmers in the Lampung area is relatively low. Besides the low application of recommended technology, we argue that this low yield was probably affected by the relatively old plantation as more than 66 per cents of the coffee trees were more than 21 years old (see. Table 3).
Table 4. Distribution of coffee plant productivity.

| Productivity (ton/ha/year) | No. of farmers | Percentage (%) |
|---------------------------|----------------|----------------|
| 0,000-0,200               | -              | -              |
| 0,201-0,300               | 1              | 4,17           |
| 0,301-0,400               | -              | -              |
| 0,401-0,500               | 2              | 8,33           |
| 0,501-0,600               | 2              | 8,33           |
| 0,601-0,700               | 3              | 12,50          |
| 0,701-0,800               | 4              | 16,67          |
| >0,800                    | 12             | 50,00          |
| Total                     | 24             | 100            |

4.2. Fertilizer application by farmers in the study area

Fertilization is an important component in Robusta coffee cultivation because nutrient fulfillment is vital for optimal coffee growth and production [28]. The survey results show that only 2/3 of the selected respondents apply organic fertilizers. Meanwhile, for inorganic fertilizers, all respondents reported that they used the fertilizer on their coffee plants. The average use of organic fertilizer is 0.325 kg per tree. This amount is lower than the use of inorganic fertilizers which reached 0.494 kg per tree. The types of inorganic fertilizers used by farmers are generally urea, KCl, SP-36, and NPK. However, the dose of inorganic fertilization is still relatively lower when compared to the recommended cultivation which reaches more than 1 kg per tree per year [28]. This finding also in line with Byrareddy, Kouadio, Mushtaq and Stone [17]’s survey in Lampung, Bengkulu and South Sumatera. However, the use of organic fertilizers is expected to be able to substitute for the nutrient needs of coffee plants derived from inorganic fertilizers. Efforts to substitute inorganic fertilizers using organic materials are an expected condition in the application of organic cultivation systems because, in addition to being able to meet plant nutrient needs, the use of organic fertilizers can also reduce production costs. After all, the prices are relatively lower and environmentally friendly [29, 30].

4.3. Determinant factors of the use of organic fertilizer in coffee farming

In order to understand how explanatory variables correlated with the use of organic fertilizers in the coffee farming system, we estimated the regression model presented in section 3.3. using STATA 16 software. The estimation results are presented in Table 5. In general, the model is quite good in estimating the use of organic fertilizers with an R-squared of 0.8085 and Prob > F of 0.003. Several independent variables that are statistically significant in influencing farmers to use organic fertilizers are the use of inorganic fertilizers, coffee farming experience, number of coffee plants, and age of coffee plants.

The regression results show that the use of inorganic fertilizers is statistically to have a negative association with the application of organic fertilizers by farmers. It means that higher application of chemical fertilizers may contribute to a lower use of organic fertilizers, and vice versa. The estimation results can also be seen as a potential in substituting the use of inorganic fertilizers with organic fertilizers. In other words, coffee farmers can reduce the use of chemical fertilizers by increasing organic fertilizers. This is important in an effort to direct farmers to change their common practices in coffee cultivation which tend to use chemical fertilizers to organic cultivation that is more environmentally friendly. In addition, the use of more organic fertilizers also has the potential to reduce coffee production costs [29, 30].
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### Table 5. Estimation results of regression models for farmers’ use of organic fertilizer.

| Variable                                | Coef. | Std. Err. | t      | P>t  | [95% Conf. Interval] | Sig. |
|-----------------------------------------|-------|-----------|--------|------|----------------------|------|
| Chemical fertilizers (g per tree)       | -0.849| 0.157     | -5.420 | 0.000| -1.183 -0.515        | ***  |
| Farmer’s age (year)                    | -11.310| 11.454    | -0.990 | 0.339| -35.724 13.104       |      |
| Experience (year)                      | 24.116| 13.041    | 1.850  | 0.084| -3.679 51.912        | *    |
| Coffee ownership (trees)               | -0.433| 0.173     | -2.500 | 0.024| -0.801 -0.064        | **   |
| Coffee tree age (year)                 | 17.908| 6.079     | 2.950  | 0.010| 4.950 30.866         | **   |
| Labor (days)                           | -68.372| 45.833    | -1.490 | 0.156| -166.062 29.318      |      |
| Coffee training (1 if yes, 0=otherwise) | 10.667| 144.208   | 0.070  | 0.942| -296.704 318.038     |      |
| Financial capital assistance (1 if yes, 0=otherwise) | -35.128| 100.476   | -0.350 | 0.731| -249.288 179.032     |      |
| Constant                                | 1,195.014| 367.244   | 3.250  | 0.005| 412.253 1,977.776    | ***  |

Note: *, **, *** significant at 10%, 5% and 1% levels.

Farming experience has a positive effect on the use of organic fertilizers. This result shows that the longer farmers are involved in coffee farming, there is a tendency to use more organic fertilizers. These results are consistent with many previous studies in the field of technology adoption which show that the longer the experience of farming, the easier it is for farmers to adopt technology [31-34]. In the context of the use of organic fertilizer in this study, with a longer farm experience, a farmer may already have more information about the benefits of using organic fertilizers, and so tend to apply more of these inputs.

The number of plants was statistically significant in influencing the use of organic fertilizers, but with a negative sign. This means that with an increasing number of coffee plants owned by the farmer, the dose level of organic fertilizer per tree will decrease. These results can be translated into the context of coffee farming economies of scale. It means that the increasing number of coffee plants owned, the more efficient the use of organic fertilizers, and vice versa. In addition, there is a tendency of mixed farming in family farming in Indonesia where farmers manage plants and livestock together [35, 36]. As a result, farmers tend to produce their organic fertilizer in the form of compost as also found by Byrareddy, Kouadio, Mushtaq and Stone [17]. As a consequence, if farmers have fewer coffee plants, then the dose of organic fertilizer for coffee plants tends to be higher and vice versa.

Regarding the relationship of tree ages with the use of organic fertilizer, Table 5 shows that farmers tend to apply more organic fertilizers to the older plants. An increase in the age of coffee plants by 1 year could lead to an increase in the dose of organic fertilizer by 17.9 grams per tree. These results indicate that farmers tend to fertilize older crops with more organic fertilizers. The estimation results also indicate that farmers are aware that the need for plant nutrients will be higher with the increasing age of the plant so that they tend to increase the dose of organic fertilizer. This is also in accordance with the recommended cultivation technology, where the dose of plant fertilization needs to be increased, especially to replace the elements lost at harvest.

5. Conclusion

Organic fertilizer is an important component of sustainable coffee farming which has become a big concern of coffee consumers. However, the rate of organic fertilizer by smallholder farmers in Tanggamus - Lampung is still relatively low. In addition to the insufficient intake of chemical fertilizer and poor farm management, coffee productivity is mostly less than 800 kg/ha/year, much lower than the potential yield can reach 3 tons/ha. This study shows that the application of organic fertilizer can substitute chemical fertilizer. Farm experience and tree age have positive significant effects on the use of organic fertilizer, while the number of coffee tree ownership has a negative relationship. In order to
increase the rate of organic fertilizer, mixed farming of coffee with livestock potentially increases compost supply for farmers which is applied to increase nutrient supply for coffee farming. This pattern is also potentially able to reduce coffee production costs.

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