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Sustainable Palm Oil Plantation Management Model: Case Study Of Palm Palm Waste Utilization

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ABSTRACT

This study aimed to determine whether sustainable palm oil plantation processing through the utilization of palm oil waste itself is very effective. This is based on the many errors in processing palm oil land that result in land damage, such as excessive use of chemical fertilizers. Data collection in this study used qualitative methods. Data collection was carried out using observation, interview, and documentation techniques. The study was conducted at PT. Padasa Enam Utama and PT. Inti Kamparindo Sejahtera. The study's findings indicate that using liquid palm oil waste and palm fronds is also very efficient. Palm oil waste will become an organic material that does not damage the soil. On the other hand, palm oil waste will also be helpful in fertilizing oil palm plants. So, using palm oil fronds as an alternative to fertilization is very good. This is because palm oil fronds will not damage the nutrients in the soil. Therefore, palm oil fronds and liquid waste can be an option in sustainable palm oil processing.

Keywords: Model, Sustainable, Palm Oil Management, Benefits of Palm Oil Waste.

INTRODUCTION

The increase in Gross Regional Domestic Product (GRDP) value is greatly influenced by palm oil. However, the conversion of green land, which causes environmental damage, is caused by significant market demand. Farmers are motivated to continue to increase palm oil production because of its essential contribution. One way to do this is to use chemical fertilizers. In Indonesia, chemical (inorganic) fertilizers have reached an alarming level because they can cause severe dependence on increased crop production. This problem is caused by the unsustainable management of oil palm plantations worldwide. The next problem is dependence on chemical fertilizers, which has encouraged the use of chemical fertilizers in various types of crop cultivation. Dependence will hurt the sustainability of smallholder oil palm plantations in the long term if it is addressed after some time (Galib et al. 2022).

For this reason, appropriate fertilizer methods are needed, such as using organic fertilizer, which directly improves the physical properties of the soil. Unfortunately, the positive effects of these fertilizers on soil physical properties are not accompanied by improvements in soil chemical properties, such as soil fertility, because organic fertilizers have low nutrient availability. However, they can also potentially improve soil's physical and biological properties. A balance of organic and inorganic fertilizers is the best way. Due to the massive use of artificial fertilizers by oil palm farmers, the dependence of oil palm plantations on artificial fertilizers has become a problem. Evidence shows that using inorganic fertilizers and other chemicals damages cropping systems by reducing soil fertility in lowland rice crops (Adrinoviarini, 2022; Nuro et al., 2016).

An imbalance in fertilizer use on oil palm plants is also reported to reduce the frequency of pest attacks, especially Ganoderma disease. Ganoderma attacks are reported to be getting worse in oil palm plantations, resulting in a decrease in plant productivity (Widiastuti and Eris, 2016; Semangun, 2000). Maintaining or conditioning the environment to suppress the growth of fungi is an approach that is now

starting to be promoted. One factor that can be a measure in maintaining overall plantation sustainability is the variable oil palm production. Sustainable plantations have enormous potential because there are still opportunities to reduce environmental and social problems (Zen, 2021; Mc Carthy dan Zen 2010).

The social, economic, and institutional sectors have benefited from the growth of the palm oil industry. However, maintaining the sustainability of oil palm plantations is a critical issue that must be addressed. The spread of Ganoderma, a disease that damages plants and reduces productivity, is one of the main challenges in achieving sustainable oil palm plantations. However, it is optional to combine all these elements to control Ganoderma in sustainable oil palm plantations by utilizing factory wastewater. However, the problem that often occurs is that the use of oil palm waste itself has yet to be an alternative farmers use for fertilization (Labibah et al., 2024).

This problem of oil palm land processing has become a serious problem experienced by waste coconut farmers. Therefore, further research is needed to test whether oil palm fronds can be an alternative to fertilization. Hence, this study tries to find a model for sustainable oil palm plantation management through a case study of the use of oil palm waste. In addition, by involving relevant stakeholders, this study will evaluate the social, economic, institutional, and environmental impacts of the application of this model.

METHODS

This study uses a case study approach to study the utilization of oil palm waste to control Ganoderma. This approach aims to understand this issue better and provide an overview of how to build sustainable oil palm plantations (Creswell, 2010; DeCuir-Bunby, 2008). Qualitative research was chosen because it can produce more in-depth data by prioritizing personal interviews with several informants to obtain an accurate picture. This study involved informants from PT. Padasa Enam Utama and PT. Inti Kamparindo Sejahtera, as well as parties related to them. Data collection used observation, interview, and documentation techniques associated with using oil palm waste.

The sampling in this study was random. Namely, it only focused on parties or plantation companies that have processed oil palm waste as an alternative to fertilizing oil palms. The study was conducted in two companies, namely PT. Padasa Enam Utama and PT. Inti Kamparindo Sejahtera because these two PTs are plantation companies that have tried and are developing the use of liquid waste to overcome oil palm fertility problems. Purposive sampling was used to select the two companies. The information provided is relevant and based on the informants' views (Taylor and Bogdan, 1998; Akhbar, 2004; Silverman, 2006; Lim, 2007; Emzir, 2009). This study also involves several procedures to achieve the predetermined objectives.

RESULTS AND DISCUSSION

Result

Ganoderma Boninense

Oil palm stem rot disease is caused by the pathogen Ganoderma boninense (Widiastuti and Eris, 2016). Symptoms appear before the fruiting body of the fungus, with rot at the base of the stem causing dry rot in the internal tissues (Semangun, 2000). Currently, oil palm plants must remain alert to stem rot disease (G. boninense), which is one of the most deadly diseases in oil palm plants in Southeast Asia. In Indonesia, this disease causes a decrease in palm oil production per unit (Angraini, 2017). Chong et al. (2011) found that root rot disease caused by G. boninense is one of the most deadly diseases in oil palm plants in Southeast Asia. In Indonesia, this disease causes a significant decrease in palm oil production per unit in several oil palm plantations.

To date, methods for controlling Ganoderma boninense have not prevented disease progression. Because Ganoderma boninense is a soil-borne pathogen with high saprophytic ability and a wide plant host range, control with technical, mechanical, and chemical cultures often fails (Nildayanti, 2011).

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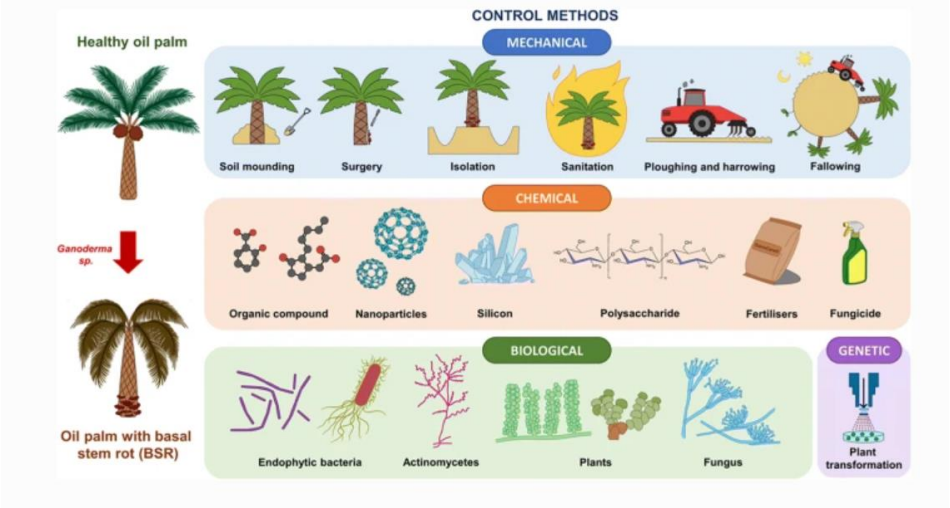

Figure 2. Ganoderma Control Methods (Supramani et al., 2022)

Leaf spot disease is another disease that attacks oil palms. Curvularia sp. is a pathogenic fungus that causes this disease (Solehudin and Suswanto, 2012). Curvularia sp. is a pathogen of various plants in tropical and subtropical regions and can cause death in the prenursery stage of oil palm plants. This can happen when treatment is not carried out (Susanto, 2013). Venita (2010) also said that Curvularia sp. is often found in significant oil palm plantations. Lalang and Syahfari (2016) stated that the attack of Curvularia sp. occurs more frequently in the main nursery than in the prenursery. Apart from being difficult to prevent, Curvularia leaf spot disease attacks will reduce the quality of the oil palm produced (Defitri, 2015).

Palm oil farmers in several Asian countries, especially Malaysia and Indonesia, which produce 85 to 90% of the world's palm oil, still experience stem rot (BPB) disease caused by the fungus Ganoderma boninense (Ishaq et al., 2014; Kurniawan and Pinem, 2017). To stop Ganoderma disease in oil palms, various techniques have been used, including the use of conventional fungicides, such as improving sanitation and destroying infected plants, as well as the use of chemicals such as carboxin and quintozene (Sahebi et al., 2015). However, until now, these various methods have yet to be completely effective because they cause side effects and damage to the environment and other beneficial living things. In addition, this method is expensive (Munthe, 2018). Ganoderma control techniques depend on how well people understand the dangers of disease in plants (Dahang et al., 2021).

Because the Ganoderma fungus can damage oil palm plants and ultimately reduce fruit production, Ganoderma can negatively impact oil palm farmers' income. Ganoderma infection can increase the resistance of oil palm plants to pests and diseases, reducing fruit quality and productivity.

The Relationship between Income and Ganoderma and Liquid Waste in Palm Oil Plantations

For oil palm farmers, Ganoderma can also be another way to make money. Some farmers choose to sell additional products, such as dried mushrooms or Ganoderma extract, which are used to make health supplements. Because Ganoderma infection affects the productivity and quality of oil palm fruit and the costs incurred to prevent and treat disease, the relationship between Ganoderma and oil palm farmer income is negative. However, oil palm farmers can also use Ganoderma as an alternative source of income.

However, to maintain palm oil production, Ganoderma growth must be stopped. Various factors, including knowledge about liquid waste and Ganoderma, can influence oil palm farmers' income. Here are some factors that might affect palm oil farmers' income if they know about liquid waste and Ganoderma :

1. Liquid waste management: Palm oil farmers who know how to manage liquid waste can improve the quality and productivity of their crops. Properly processed liquid waste can be used as organic fertilizer rich in nutrients, improving the quality and growth of oil palm plants. Good liquid waste management can also prevent environmental pollution and increase the sustainability of their business.
2. Ganoderma Infection: Oil palm farmers who know about Ganoderma and how to prevent and treat this infection can reduce the costs of dealing with its adverse effects on their crops and reduce the risk of losing production and quality of their fruit.
3. Marketing of co-products: Oil palm farmers who spend on co-products can use this knowledge to take adequate preventive measures.

Overall, knowledge about wastewater and Ganoderma can directly or indirectly impact the income of oil palm farmers, depending on how they use and apply this information in the management of their business. Factors that impact Ganoderma :

1. Environmental Conditions: Humid and tropical environments allow Ganoderma to reproduce and spread. However, too wet or dry environments can affect Ganoderma's development in plants.
2. Plant health: Healthy and robust plants have strong immunity to Ganoderma infections, while weak or too old plants are more susceptible to disease.
3. Soil quality: Poor soil quality can affect plant health and productivity, increasing the risk of Ganoderma infection.
4. Sanitary conditions: Sanitary conditions in the planting area can also influence the risk of Ganoderma infection.
5. Use of fungicides: Using fungicides can control Ganoderma infections in plants, but excessive or inappropriate use can harm plants and the surrounding environment.
6. Farmer knowledge: Farmers can influence the risk and impact of infections on plants and the costs of preventing and treating diseases based on their understanding of Ganoderma, including how to prevent and treat illnesses.
7. Utilization of Ganoderma: Farmers can use Ganoderma as an alternative source of income by selling dried mushrooms or Ganoderma extract as additional products. Utilizing Ganoderma can also produce financial benefits. Increasing the body's immunity is one of the main benefits of ganoderma mushrooms. Laboratory studies show that ganoderma fungus can affect white blood cells, an essential part of the immune system for fighting infections.

Palm Oil Mill Liquid Waste

Farmers often use synthetic chemical fungicides as the central control. This is done because it is easy and produces good results (Angraini, 2017). However, synthetic fungicides are considered less effective for controlling G. boninense (Widiastuti and Eris, 2016) and Curvularia sp. Long-term use of synthetic fungicides causes resistance, resurgence, and residues dangerous to environmental sustainability (Susanto, 2013). Due to the adverse side effects of synthetic fungicides, more environmentally friendly alternatives are needed. One way is to use liquid waste from palm oil mills as a fungicide to combat pathogens that cause stem rot and leaf spot diseases in oil palms (Widhiastuti et al., 2006).

Palm oil liquid waste is the remainder of the oil palm plant, not included in the main product or by-product of the palm oil processing process. This is a type of organic waste produced when fresh fruit bunches (FFB) are processed into crude palm oil (CPO) or crude palm oil (Yacob et al., 2015). Palm oil liquid waste is the remainder of the oil palm plant, not included in the main product or by-product of the palm oil processing process. Liquid waste is processed in several ponds at the palm oil mill. These include fat ponds, cooling ponds, bacterial breeding ponds, acidification ponds, aerobic and anaerobic breakdown ponds, sedimentation ponds, and land use (Hanim et al., 2020). Liquid waste from palm oil mills contains nutrients such as N, P, K, Mg, and Ca. Therefore, this liquid waste can be used as a source of nutrients for oil palm plants in addition to providing moisture to the soil and improving the physical and chemical properties of the soil (Mulia Raja et al., 2021).

This palm oil factory produces liquid waste, which can be used as fertilizer because plants can use its nutrient content as a nutrient source. This liquid waste also contains nitrogen, phosphorus, potassium, magnesium, and calcium. Nutrient elements that are often found in palm oil mill wastewater are N (450-590 mg L-1), P (92-104 mg L-1), K (1,246-1,262 mg L-1) and Mg (249- 271 mg L-1) (Ideriah et al., 2007).

Discussion

Management of Plantation Companies

To ensure the sustainability of the palm oil business, efforts to manage palm oil plantations must meet standards. To achieve this goal, the Indonesian government has issued part of Presidential Regulation No. 44 of 2020 concerning the Indonesian Sustainable Palm Oil Plantation Certification System. Efforts to encourage sustainable palm oil plantations have entered an urgent period, and the development of sustainable smallholder oil palm plantations is significant in meeting sustainable management standards certified by Indonesia Sustainable Palm Oil (ISPO). The deadline set for sustainable management of smallholder plantations is 2025. After this period, fulfillment of ISPO principles and criteria becomes a requirement.

The ISPO certification mechanism requires the implementation of five principles and thirty indicators. Because farmers' readiness level to carry out certification still needs to be higher, implementing ISPO is difficult. Because oil palm farmers have yet to be ready and face many obstacles in fulfilling the assessment aspects, implementing ISPO certification without being followed by improvements and assistance in managing oil palm plantations has the potential to exclude them. There is an urgent need to encourage

sustainable management of oil palm plantations. People's plantations must achieve sustainable management before 2025. After that, compliance with ISPO principles and criteria will become mandatory. ISPO certification requires the application of five principles and thirty indicators. Because farmers are not ready to undertake certification, implementing ISPO is difficult. As a result, efforts to obtain ISPO certification without assistance and improvements in oil palm plantation management can exclude oil palm farmers who are not ready and face obstacles in fulfilling aspects of the assessment.

Palm oil has high economic value because the fruit can be processed into semi-finished products such as crude coconut oil (CPO) and coconut kernel oil (PKO). However, oil palm plantations also face major environmental problems. About half of the current eight million hectares of productive plantations have been established through previous deforestation. The Indonesian government created a sustainable palm oil certification standard known as ISPO. This standard is regulated by Minister of Agriculture Regulation No. 11/Permentan/OT.140/3/2015 concerning the Indonesian Sustainable Palm Oil Certification System (ISPO) (Imansari, 2015). The legality of plantation businesses, plantation management, protection of the use of primary natural forests and peatlands, environmental management and monitoring, employee responsibility, social responsibility, community economic empowerment, and increasing sustainable business are the seven principles of ISPO (Dewi, 2014).

The three principles of ISPO are the legality of plantation businesses, plantation management, and environmental monitoring and management. The principle of business legality is fundamental to keeping the business legally valid and recognized by the state. To maintain the quality and quantity of Fresh Fruit Bunches (FFB), CPO, and kernels, plantation management principles must be applied. Meanwhile, the company is responsible for monitoring and managing the environment so that the FFB, CPO, and kernels produced can be considered environmentally friendly. Companies can ensure good plantation management by implementing these principles (Imansari, 2015).

Palm Oil Farming Income

Income is one of the leading economic indicators in measuring a person's abilities. Income measures all money or other material resulting from the wealth or services received by an individual or household over a certain period in an economic activity (Winardi, 1998). Everyone who works will try to obtain maximum profits to fulfill their daily needs. The main goal of workers willing to do various jobs is to earn sufficient income so that their living or household needs can be met/achieved.

Because more than 55% of Indonesia's population works as farmers, such as oil palm farmers (Pranoto, 2002; Setyamidjaja and Djoehana, 1991), the agricultural sector plays a vital role in national economic development. As a result, the income earned by farmers in the farm sector is called farming income. Two different categories of farming income: (1) gross income, which is the farmer's total income for one year of farming calculated from sales or exchange of production results, which are valued in rupiah based on the price per unit weight when harvesting; and (2) net income, which is the farmer's total income for one year of farming minus production costs during the production process (Gustiyana, 2004). Farming income consists of two components: farming receipts and expenses. Production is related to revenue and costs; revenue is deducted from the total expenses incurred during the production process (Mubyarto, 1989). On the other hand, expenditures or expenses are intended to determine the value of using production facilities and other fees (Ahmad, 2001).

Farming income is still considered more minor than non-farming (Andriani, 2017). However, farming income can be increased by increasing agricultural production, such as fertilization. This is because fertilization, such as NPK fertilizer, can increase farm productivity and improve farmer welfare in terms of income (Pulungan et al., 2020), Additionally, improving marketing performance and competitive strategies that can be applied to farming businesses can increase income (Savitri and Natariasari, 2021). Competitive strategies include providing skills training and mentoring, competitive advantage, and competitor intelligence (Savitri and Natariasari, 2021). In addition, it is considered that increasing marketing performance, capital, and land area can significantly increase farmers' income (Kosmayanti & Ermiati, 2017; Damanik, 2014). Capital in farming can be defined as wealth in the form of money or goods used to produce something in the production process, either directly or indirectly (Soekartawi, 2002).

This study was conducted by Pratiwi et al. and was titled Analysis of Palm Oil Farming Income (Elaeis guineensis Jacq.) in Waru District, North Penajam Paser Regency. The results show that oil palm farming earns an average of 19,882,641.92 rupiahs per year per ha (Pratiwi, DA Maryam, S. Balkis, 2020). According to the R/C ratio value of 4.44, or greater than 1, the palm oil business in Waru District is considered economically profitable. This means that farmers will generate an Rp income of 4,440.00 for each additional fee of Rp. 1,000.00. Apart from that, the Cattle and Oil Palm Integration System's land area can also increase oil palm farmers' income (Sirait et al., 2015). Thus, it can be explained that oil palm cultivation

can potentially improve the standard of living and income for both large companies and small farming households (Chrisendo et al., 2022).

Per hectare plantation production influences the income of oil palm farmers. Plant performance in the field, characterized by variable fruit per plant, determines production. The parent's genes affect the quality and quantity of oil palm fruit. Only from high-quality seed sources can species of high genetic quality be obtained. Very diverse field management variables will also influence the expected final yield of palm oil products. Production decreases significantly when plants are attacked by disease, especially ganoderma disease. Various mechanical and chemical techniques have been used to treat Ganoderma disease, but they have failed to significantly stop the fungus's growth. Using chemical drugs can hurt plants and the environment in the long term, according to sustainable agriculture principles. Methods combining organic fertilizer can be a new approach to stopping the spread of root diseases (Mulia Raja et al., 2021; Ideriah et al., 2007)

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Sustainable Agriculture Concept

Sustainable agriculture is vital for agricultural progress, especially in smallholder oil palm plantations. We now know that various palm oil agribusiness systems require a sustainable approach. For example, oil palm plantations are often discussed by the international community as destroying the environment and forests. North Sumatra especially plays a significant role in developing smallholder oil palm plantations. Since colonial times, plantations have been the region's leading commodity. The conversion of non-palm plantations to oil palm causes many problems, which increases the challenge of ecosystem sustainability.

According to data from the Directorate General of Plantations, Ministry of Agriculture of the Republic of Indonesia (Ditjenbun, 2022), the area of smallholder oil palm plantations in North Sumatra reached 441,400 ha, or 7.3 percent of the total area of Indonesian smallholder plantations (6,044,058 ha). Community palm oil production reached 1,583,945 tonnes, or 10.2 percent of national palm oil production (15,495,427 tonnes). 2,558,741 people work on smallholder oil palm plantations, with 192,307 people in North Sumatra. This is still smaller than the provinces of Riau, Jambi, West Kalimantan, and South Sumatra, but its productivity is 4,124 kg/ha higher than Bengkulu and South Sumatra.

Suppose a sustainable agricultural and plantation approach does not accompany the development of oil palm plantations. In that case, it is hoped that it will positively impact society's ecological and socio-economic systems in the long term. Systems that are not appropriately managed will sooner or later break down, reducing quality and output. Farmers and regions that depend on plantation PAD, such as North Sumatra province, are experiencing economic losses. Land degradation can also cause a decrease in land and area quality and cause unproductive critical land to appear. It has become a hidden problem for the region and Indonesia. Therefore, it is essential to apply the concept of sustainable agriculture in oil palm plantations.

Sustainable agriculture relies on three elements: ecology, economy, and socio-culture. Sustainable agriculture can only succeed as an ecological measure by gaining socio-cultural support from local communities. Therefore, sustainable agriculture is fundamentally related to the behavior of local farmers. Many studies have concentrated on sustainable agriculture relative to physical variables, but it is rarely seen as a social activity.

Based on the meaning above, sustainable agriculture aims to guarantee farmers' income so that agricultural output does not decrease as income. The primary strategy for sustainable agriculture is to generate revenue that occurs in the short, medium, and long term. Current aspects of farmer income often conflict with ecological sustainability. Increasing land input every year is an effort to improve general income. Therefore, efforts to maintain garden yields are always accompanied by efforts to increase land input. However, with limited land carrying capacity, continuous input will damage the soil as a medium for plant growth. In agricultural soils, many high inorganic and chemical inputs are added. Activities here can increase crop yields quickly, but in the long term, they actually reduce the land's carrying capacity. There are many cases where productive land turns into abandoned land due to a decrease in fertility levels characterized by the growth of reeds.

Sustainable agricultural development is part of sustainable development. It aims to meet the current generation's needs without compromising the system's ability to meet future needs. If system capabilities continue long-term, sustainable development is considered successful. Placing humans as the subject of development, this model is called human-centered development. Therefore, sustainable development aims to build a society that needs to progress, be independent, and be prosperous.

Viewed from an ecological perspective, the priority of sustainable development is the development of environmental systems that can survive in the long term. In other words, the ecosystem is not damaged because the aim is to obtain agricultural products and land. Various farming methods have been used to ensure the ecosystem is not damaged, such as conservation farming, intercropping, or the alley model of agriculture, which combines different crops. The level of erosion on land facilitated by multistory canopy strata will be lower with the combination of these types. As a result, rainwater can be received by the soil and continues to be absorbed into the soil. From an economic perspective, sustainability here is demonstrated by consistent productivity over the long term, even between generations. Degradation of agricultural land will stop sustainable productivity.

Ecological sustainability means no environmental damage or damage to the land. Overall, the quality of natural resources and agroecosystems can be maintained. The method is conservation farming to improve farming management. Sinukaban (1999) stated that a conservation farming system can ensure sustainable agriculture by complementing farming with conservation practices. This improved agricultural system can guarantee high productivity and income, low erosion rates, and agricultural technology that is easy to use and apply. For the system to be sustainable, combining local farmers' knowledge in applying planting practices (conservation) that suit local problems is essential. Farmers' understanding of local

agroecology and crop cultivation practices prioritizing conservation is also crucial for the system's success (Partohardjono, 1999).

The farming pattern provides stability and development for society and communities because the socio-cultural aspect emphasizes community values. Compatibility of culture, tradition, and social structure is essential for the system's sustainability. A strategy is needed that involves local communities in determining the technology and farming management required. Farmers no longer consider increasing production and income to solve their problems (Raintree, 1990).

According to several studies on sustainable agricultural practices, organic farming is considered suitable for economic, social, and environmental aspects in Sub-Saharan Africa (Kleemann, 2013). To meet the increasing demand for food, fiber, wood, and animal fodder and make the environment healthier, various crop types are carried out in farming operations in Malaysia. This results in more promising income for farmers (Bachal Jamali et al. 2011). The research results show that the factors hindering sustainable agriculture can cause environmental changes (Knutson et al., 2011). Biggelaar (2000) states that conventional sustainable agricultural technologies and practices can increase crop and livestock production with minor environmental damage (Biggelaar, 2000). However, their effects on society and the institutions where they are implemented are still unclear. Kumbhar et al . (2012) and Bruges et al. (2008) show that policies are critical to generating sustainable agricultural technology transfer and effective natural resource management.

The main actors in sustainable agriculture are farmers. A positive mentality and sufficient knowledge and support from other parties are needed to achieve this. Owubah et al. (2001) state that only some farmers undertake sustainable resource management practices when they receive adequate incentives. Economic compensation is essential to adopting and implementing sustainable practices. The sustainable agriculture approach emphasizes that these three factors must exist simultaneously. Community rubber management has a partial and unsustainable impact on various problems, including low production, portions of old rubber, ineffective marketing, and procurement of high-quality seeds and inputs (Siregar et al., 2012). This is related to controlling the resource in question, in this case, smallholder oil palm plantations. If the control system can guarantee that the community has the right to control these resources, farmers can be innovative in developing systems, including sustainable management.

Local farmer institutions that recognize community rights to land and plantations or protect them will provide guarantees. This can be achieved if users can create their institutions according to some basic designs. In this way, they can manage their institutions continuously over a long period. If a resource has strong ties to its users, if users understand their problems, and if they have the freedom to create their own rules and various other features, this self-organization is likely to occur (Ostrom, 1999).

Preliminary Study and Results Achieved

To support a sustainable system, various efforts have been made to support the use of organic fertilizer. Organic fertilizers show many benefits for plant growth and yield. Evidence shows that using organic materials can increase rice yields (Bachtiar et al., 2020; Amiroh et al., 2018; Galib et al., 2022). According to Eliyanti's research, using organic fertilizer can reduce the use of inorganic fertilizer. Capital problems also often limit efforts to improve plantation products (Hariyadi et al., 2009). Controlling the use of balanced fertilizer can be achieved through cultivating healthy plants, which includes balanced fertilization, regular pruning of plants and protective plants, and regulation of companion plant populations. Biological control can be achieved through black ants and the Beauveria bassiana fungus, and mechanical power can be achieved through fruit covering.

To encourage sustainable management in smallholder oil palm plantations, a strategy of balancing organic and inorganic fertilizers can be used. Perennial plants typically depend on other environmental variables that promote growth, development, and soil fertility. Smallholder oil palm farmers can apply this principle by using various cultivation methods. This rationale shows that fertilizer use is greatly influenced by farmers' social, economic, and cultural conditions and is not only aimed at increasing crop yields. Farmers must be able to apply various fertilizer-balancing technology approaches to improve plants' environmental conditions and not just increase soil fertility.

Fertilation is carried out to maintain plant fertility and distribute nutrient elements in a balanced manner to plants directly or indirectly in the soil. The goal is to produce the best fresh fruit bunches (FFB) and oil quality according to the plant's potential. Lack of nutrients causes a reduction in vegetative growth, plant productivity, and disease and pest resistance. Fertilization provides sufficient nutrients to encourage healthy vegetative growth and FFB production to reach maximum productivity (Sutarta, 2002). Fertilization can also help maintain ideal soil conditions for oil palms' growth and development and replace nutrients plants absorb (Arsyad and Junedi, 2012).

Fertilization is essential for increasing production. The costs incurred by fertilization range from forty to sixty percent of plant maintenance costs, and more than fifty percent may be allocated for this

purpose (Hakim, 2007). Fertilizing oil palm plants must ensure average vegetative and reproductive growth to achieve optimal fresh fruit (FFB) production and high quality and quantity of palm oil (Adiwiganda, 2007). The fertilizer's age and work experience do not affect FFB production, but the amount of fertilizer used in a year positively correlates with FFB. The Labor Index of 0.1508 Hk Ha is used efficiently on this plantation (Budiargo et al., 2015).

Fertilization accuracy refers to the accuracy of dose, type, time, method, and price, as well as the effectiveness and efficiency of fertilization. Fertilization is adequate if the plant absorbs most of the fertilizer nutrients. Fertilizer efficiency is related to the relationship between costs and the level of production produced (Pardamean, 2014).

Analysis of the plant's nutrient needs through soil and leaf analysis is necessary before fertilizing to meet the plant's nutrient needs (Pahan 2008). When fertilizing, there may be a nutrient imbalance in the soil, leading to increased FFB production and decreased FFB weight per tree. If the fertilizer dose is based on production potential, FFB production can increase at B4 and B6 doses (Ar et al., 2012). Each ton of FFB contains nutrients equivalent to 6.3 kilograms of urea, 2.1 kilograms of TSP, 7.3 kilograms of KCL, and 4.9 kilograms of kieserite. Please must be returned as fertilizer to ensure proper nutrient availability.

CONLUSION

Based on the analysis of oil palm plantation processing, it was found that many oil palm farmers need to improve at utilizing liquid waste as a fertilizer for oil palm. It was concluded that the effectiveness of using liquid waste can provide opportunities for success and good benefits for land sustainability. Plantation management practices utilizing oil palm fronds also help fertilize oil palms. The potential for increasing or improving land that is already low in nutrients can certainly be increased with more sustainable management, including using Ganoderma, which has successfully overcome several farmer problems. Oil palm farmers must maximize the use of Ganoderma as an alternative in oil palm plantation maintenance. In addition to using oil palm fronds, farmers must maximize the processing of fronds as one of the materials for oil palm fertilization.

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