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Analysis of Processing Empty Oil Palm Fruit Bunch Waste (EFB) Into Organic Fertilizer and Organic Mulch

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Abstract: *Fresh fruit bunches (FFB) of oil palm are processed into crude palm oil (CPO) and palm oil waste. Palm oil waste, such as empty fruit bunches (EFB), has traditionally been incinerated, leading to increased carbon emissions in the atmosphere. However, EFB can be utilized as organic fertilizer and mulch for oil palm cultivation. This study aims to analyze the conversion of EFB waste into organic fertilizer and mulch. The research was conducted at PT Perkebunan Nusantara VII Kertajaya, Banten Province, from July 2023 to August 2024. A qualitative descriptive approach was employed, with data collected through observation, interviews, and documentation. Participants were selected using purposive sampling, involving 20 individuals. The results indicate that the process of converting EFB waste into organic fertilizer and mulch comprises two main stages: (1) the processing of FFB into EFB waste, which includes the following steps: a) weighing, b) sorting, c) loading ramp, d) sterilization, e) stripping, and f) empty bunch hopper; and (2) the transformation of EFB waste into organic fertilizer and mulch. The production process for organic fertilizer and mulch occurs naturally. The EFB waste is applied as organic fertilizer and mulch by spreading it on the soil around the oil palm trees.*

Keywords: *Palm oil waste; Empty Fruit Bunches (EFB), Organic Fertilizer; Mulch.*

1. INTRODUCTION

Indonesia is the largest producer and exporter of palm oil in the world. More than five percent of the global demand for palm oil is met by Indonesia, placing the country among the top ten palm oil-producing and exporting nations globally (Abdul, 2023). According to data from the Directorate General of Plantations, the total area of oil palm plantations in Indonesia between 2020-2022 reached 15,380,981 hectares, with a total production of 48,235,405 tons and an average productivity of 3,903 kg/ha (Ministry of Agriculture, 2022). Banten Province is one of the regions in Indonesia with oil palm plantations. Although it is not one of the largest contributors to palm oil production in the country, its presence is noteworthy. In 2022, Banten Province had a plantation area of 19,556 hectares with a production output of 24,033 tons (Ministry of Agriculture, 2022).

PT Perkebunan Nusantara VII Kertajaya, a business unit of PTPN IV, operates in the palm oil processing sector in Lebak. The company has an average maximum production capacity of 30 tons of fresh fruit bunches (FFB) per hour. Fresh fruit bunches are processed into crude palm oil (CPO) and palm waste. Palm waste consists of solid and liquid residues. Liquid palm oil waste, a by-product of FFB processing into crude palm oil, generates biogas and electricity. Solid waste

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includes Empty Fruit Bunches (EFB), fiber, shells, palm trunks, and kernel cake. The volume of solid waste produced is directly proportional to the amount of FFB processed, with every ton of FFB generating 22-23% EFB, equivalent to 220-230 kg.Currently, palm oil waste management at PT Perkebunan Nusantara VII Kertajaya is suboptimal. Most palm oil mills in Indonesia employ incinerators to burn EFB, which contributes to environmental issues such as increased carbon emissions and air pollution (Putri *et al*., 2023). Burning EFB releases fly ash, which causes air pollution (Adiguna *et al*., 2020). Therefore, preventive measures are necessary to mitigate these adverse effects and promote environmentally friendly industrial practices.

The by-products or waste from the palm oil industry can be utilized sustainably. Empty Fruit Bunches (EFB) have significant potential to enhance soil fertility and crop productivity due to their composition, which includes 45.95% cellulose, 22.84% hemicellulose, 16.49% lignin, 2.41% oil, and 1.23% ash. There are two alternative solutions to address EFB waste: safe disposal or processing into valuable materials. One effective application of EFB is as organic mulch and organic fertilizer, which can directly impact soil evaporation (Juanda *et al*., 2020). Organic mulch, made from plant residues, serves as a soil cover material. It helps improve fertility, enhance soil aggregation and porosity, and retain nutrients by preventing erosion from rainwater (Susiawan *et al*., 2018). Organic fertilizer, derived from decomposed plant residues, animal manure, or other organic waste, undergoes engineering processes to become solid or liquid forms. It can be enriched with minerals or beneficial microbes to improve soil nutrient content and enhance the physical, chemical, and biological properties of the soil. The application of organic fertilizer in cultivated plants can increase soil productivity as organic matter improves soil structure, physics, and biology. Based on the background above, serious attention to solid waste (Empty Fruit Bunches or EFB) is essential. One potential solution is utilizing solid waste as organic fertilizer and mulch. This study aims to describe the process of converting EFB waste into organic fertilizer and organic mulch.

2. RESEARCH METHOD

The research was conducted at PT Perkebunan Nusantara VIII Kertajaya, located in Leuwi Ipuh Village, Banjarsari Subdistrict, Lebak Regency, Banten Province. The research period extended from July 2023 to August 2024. A descriptive qualitative approach was employed in this study. Research instruments included observation sheets, documentation, and interview guidelines. Data collection techniques comprised observations, interviews, and documentation. Observations were used to examine activities related to processing oil palm empty fruit bunches (EFB) into organic fertilizer and organic mulch. Interviews were conducted to gather information from participants about the process of transforming EFB into organic fertilizer and mulch. Meanwhile, documentation aimed to collect accurate evidence related to research activities.

Participant recruitment was carried out using a purposive sampling technique, taking into account various criteria and research objectives. The criteria for participant selection included employees of PT Perkebunan Nusantara VIII Kertajaya, Lebak Regency, Banten Province, who possessed knowledge about making mulch and organic fertilizer from EFB waste, as well as having a minimum of five years of experience in processing EFB waste. A total of 20 participants were involved in the research, consisting of Processing Assistants, Acting Supervisors of the Laboratory, Division Assistants, Supervisors I, Maintenance Supervisors, Harvest Density (AKP) Officers, and Harvesters.

The research process consisted of three stages: the pre-research stage, the fieldwork stage, and the data analysis stage. The pre-research stage involved activities carried out before data collection, including preparing the research design, selecting the research site, obtaining permissions, assessing and exploring the field, and preparing research equipment. The fieldwork stage focused on data collection based on the research problems and objectives, using observations, interviews, documentation, and triangulation methods. The final stage, data analysis, involved systematically organizing and

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analyzing the data obtained during the fieldwork stage to draw conclusions.

3. RESULTS AND DISCUSSION

The research gathered information on the process of converting Oil Palm Empty Fruit Bunch (EFB) waste into organic fertilizer and organic mulch through observation, interviews, and documentation at PT Perkebunan Nusantara VII Kertajaya, Lebak Regency, Banten Province. The study involved 20 participants.

Figure 1. Fresh Fruit Bunch (FFB)
(Source: InfoSAWIT, 2022)

Figure 2. Oil Palm Empty Fruit Bunch (EFB)
(Source: Personal Documentation)

Fresh Fruit Bunches (FFB) of oil palm are parts of the oil palm plant containing palm fruits (Figure 1). FFB are obtained during the harvesting process. After harvesting, FFB are processed into various products such as Crude Palm Oil (CPO). The processing of FFB not only produces CPO but also generates significant by-products, including waste. For every ton of processed oil palm, the waste includes 23% or 230 kg of Empty Fruit Bunch (EFB), 6.5% or 65 kg of palm shells, 4% or 40 kg of palm sludge, and 13% or 130 kg of fiber. Observations, interviews, and documentation revealed that the process of converting Oil Palm EFB (Figure 2) into organic fertilizer and mulch involves two main stages: (1) Processing FFB into EFB and (2) Processing EFB into organic fertilizer and mulch. The process of converting FFB into EFB comprises five steps. The diagram below (Figure 3) outlines the process.

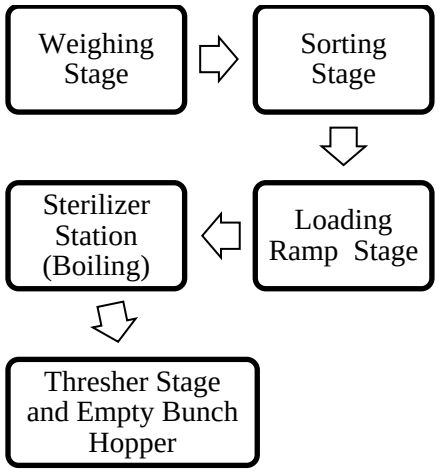

Figure 3. Process Flow of Converting FFB into EFB

Explanation of the FFB to EFB Conversion Process:

1) Weighing Stage

This stage begins with the receipt of fresh fruit bunches (FFB) from the plantation of PT Perkebunan Nusantara VII Kertajaya, Lebak Regency, Banten Province. Next, before entering the processing section, the fresh fruit bunches (FFB) are weighed to determine the weight of the palm oil fresh fruit bunches received by the factory using a weighbridge. The function of the weighbridge is to measure the weight of raw materials for the palm oil process, weigh the production of crude palm oil (CPO) before it is sent to buyers, and weigh by-products such as solids, empty fruit bunches (EFB), shells, or compost that will be sent to the estate (plantation). Afzal *et al.*, (2022) explained that a weighbridge functions to measure the weight of a truck when it is empty and when it is loaded with palm oil fresh fruit bunches (FFB).

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Figure 4. Weighbridge Station
(Source: Personal Documentation)

2) Sorting Stage

The sorting stage is the process of selecting fresh fruit bunches (FFB). Sorting is conducted to determine the quality of the fresh fruit bunches (FFB) from each vehicle entering the factory. The quality assessment of the fresh fruit bunches (FFB) is carried out manually by taking samples from each vehicle unit. Samples taken from small vehicles consist of 60 loose fruits, while for larger vehicles (trucks), 120 loose fruits are sampled. The purpose of sampling is to determine the quality of the fresh fruit bunches (FFB), which directly affects the quality of the fruit. If the fresh fruit bunches (FFB) meet the requirements, they will be accepted by the factory. Conversely, if they do not meet the requirements, they will be rejected. The fresh fruit bunches (FFB) accepted by the factory will be stacked in the loading ramp area and then placed into trolleys for processing (Rizky *et al*., 2014).

Figure 5. Sorting Station
(Source: Personal Documentation)

3) Loading Ramp Stage

The loading ramp stage takes place at the loading ramp station. This location serves as a temporary storage area for palm oil fresh fruit bunches (FFB). The station has two lands: the first land has 12 doors, and the second land has 8 doors. These doors are opened to allow the fresh fruit bunches (FFB) to enter the fruit cages (lori). Each lori has a capacity of 2.5 tons. The function of the loading ramp is to serve as a temporary holding area for palm oil fresh fruit bunches (FFB) before they are loaded into the fruit cages. Generally, the loading ramp consists of two lines with 12 doors, each with a capacity of 15 tons, and an overall holding capacity of approximately 360 tons of fresh fruit bunches (FFB). The loading ramp floor area measures 40 × 22 meters (two lines) and can accommodate up to 400 tons of fresh fruit bunches (FFB). The loading ramp is designed with a slope of 25° to 27°, facilitating the smooth sliding of the fresh fruit bunches (FFB) into the lori (Purwoto, 2024).

Figure 6. Loading Ramp Station
(Source: Personal Documentation)

Figure 7. Fruit Cages (Lori)
(Source: Personal Documentation)

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4) Sterilizer Station (Boiling)

After the temporary storage stage, the fresh fruit bunches (FFB) are heated or sterilized at a temperature of 130°C. This sterilization process is carried out in a large vessel using steam injection (steam pressure of 2.5-3.0 atm) for approximately 90-100 minutes. The sterilization process serves several purposes: it destroys lipolytic enzymes (catalysts) that break down oil into free fatty acids and glycerine, facilitates the detachment of the fruit from the stalks or bunches, softens the fruit flesh to ease the pressing and purification of the oil, simplifies the separation of the shell from the kernel, and helps precipitate mucilage (protein substances) with emulsifying properties, thereby making it easier to separate oil from water.

Figure 8. Sterilizer Station
(Source: Personal Documentation)

5) Thresher Stage and Empty Bunch Hopper

The thresher stage is the process of separating the fruit from the bunches using a fruit stripping machine in the form of a cylindrical drum (rotating at 23 rpm). The boiled fresh fruit bunches (FFB) are separated into fruit and empty bunches by being tossed into the thresher drum. The loose fruits are directed into the pre-elevator and then into the digester (tube), where blades inside the tube separate the pulp and the kernel. Meanwhile, the empty bunches are transported by the empty bunch conveyor to the empty bunch hopper (the empty bunch collection station), which serves as a temporary storage area for palm oil fresh fruit bunches (FFB) before being transported by trucks for distribution to the plantations.

Figure 9. Threser Station
(Source: Personal Documentation)

Figure 10. Empth Bunch Hooper Station
(Source: Personal Documentation)

After processing fresh fruit bunches (FFB) into oil palm empty fruit bunch (EFB) waste, the next step is processing the empty fruit bunch (EFB) waste into organic fertilizer and mulch. Figure 11 illustrates the stages of producing organic fertilizer from oil palm empty fruit bunch (EFB) waste. Stages of Processing Oil Palm Empty Fruit Bunch (EFB):

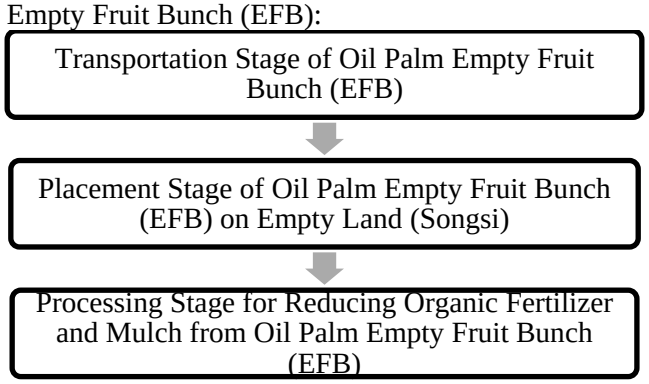

Figure 11. Stages of producing organic fertilizer from oil palm empty fruit bunch (EFB) waste

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The following are the stages of producing organic fertilizer from oil palm empty fruit bunch (EFB) waste:

1) **Transportation Stage of Oil Palm Empty Fruit Bunch (EFB)**: After passing through the Thresher Stage and the Empty Bunch Hopper, the oil palm empty fruit bunch (EFB) is transported by truck to empty land (songsi), designated as the placement area. Nugraha (2018) stated that oil palm empty fruit bunch (EFB) waste, once separated from the fruit, is then transported to a storage area to be processed into organic fertilizer.
2) **Placement Stage of Oil Palm Empty Fruit Bunch (EFB) on Empty Land (Songsi)**: After transporting the oil palm empty fruit bunch (EFB) from the Thresher Station and Empty Bunch Hopper, the EFB is moved from the storage area to be applied to the field. This process must be carried out promptly because the decomposition and mineralization process of EFB by microorganisms is relatively slow. Among the four nutrients contained in EFB, potassium (K) decomposes the fastest. Therefore, EFB stored in the storage area must be immediately applied to the field. If the EFB is stored for too long, the potassium (K) content will be quickly lost due to its high rate of decomposition.

Figure 12. Placement or temporary storage of Oil Palm Empty Fruit Bunch (EFB)

Figure 13. Oil Palm Empty Fruit Bunch (EFB) placed on empty land (songsi).

3) **The Process of Decomposition of Organic Fertilizer and Mulch from Oil Palm Empty Fruit Bunch (EFB) Waste**: After the placement of oil palm empty fruit bunch (EFB) on empty land (songsi), the next step is the decomposition process of the EFB into organic fertilizer and mulch. Based on observations at PT Perkebunan Nusantara VII Kertajaya, Lebak Regency, Banten Province, the production of organic fertilizer and mulch at this company takes place naturally or conventionally without any assistance. The oil palm empty fruit bunch (EFB) is placed around the soil or the growing area of the palm oil plants themselves. Interviews with several participants revealed that EFB, when shredded by machines, is less effective as organic fertilizer or mulch. Therefore, PT Perkebunan Nusantara VII Kertajaya, Lebak Regency, Banten Province, utilizes EFB waste for organic fertilizer and mulch in a natural and conventional manner. The oil palm empty fruit bunch (EFB) is used as both organic fertilizer and mulch for the oil palm plants at PT Perkebunan Nusantara VII Kertajaya, Lebak Regency, Banten Province. Naturally, EFB waste requires a relatively long time for decomposition. The process of breaking down into organic fertilizer can take up to one year (Herwin, 2013). Therefore, the processing of EFB needs to be carried out with consideration for environmental sustainability (Adiguna *et al.*, 2020). One solution to address this issue is the use of EM4 microorganisms, which are effective in accelerating the composting process (Akbarsyach *et al.*, 2020). When

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applied to agriculture, oil palm empty fruit bunch (EFB) waste has several advantages, including improving soil structure to make it more loose, aiding in the solubility of nutrients necessary for plant growth, promoting the biological development of soil organisms such as microbes and earthworms, and reducing the risk of spreading plant pests. As the microbial condition of the soil and physical soil fertility improves, nutrient absorption by roots increases, resulting in better growth of oil palm plants (Herwin, 2013). Oil palm empty fruit bunch (EFB) waste also has potential in bioindustry development due to its high lignocellulose content, which can produce xylanase enzymes, bacteria, and fungi (Hatta *et al.*, 2014). EFB waste processed into organic fertilizer has several benefits, including: 1) helping in the solubility of nutrients needed for plant growth, 2) being homogeneous and reducing the risk of carrying plant pests, 3) being resistant to leaching by water, and 4) being applicable in various seasons (Fauzi *et al.*, 2002).

Figure 14. Mulch from Oil Palm Empty Fruit Bunch (EFB) that has been aged for 2 months

Oil palm empty fruit bunch (EFB) waste can be utilized as organic fertilizer and organic mulch for the palm oil plants themselves. Organic fertilizer is derived from decayed plants, animal manure, or other organic waste that has undergone engineering processes. It can be in solid or liquid form, enriched with mineral substances or beneficial microbes to increase nutrient content and improve the physical, chemical, and biological properties of the soil (Permentan, 2011). Oil palm empty fruit bunch fertilizer, as a type of organic fertilizer, is made from organic materials and contains essential nutrients such as nitrogen (N), phosphorus (P), potassium (K), and magnesium (Mg), as well as trace elements (Akbarsyach *et al.*, 2020). Organic mulch is a soil-covering material derived from plant residues. Mulch helps improve soil fertility, enhance aggregation and porosity, and preserve soil nutrients from erosion caused by rainfall (Susiawan *et al.*, 2018). According to Gustanti *et al.* (2014), the application of mulch on the soil or agricultural land surface can protect the soil's top layer from direct exposure to intense sunlight and heavy rainfall. It also reduces competition between crops and weeds for sunlight and prevents evaporation, ensuring water loss occurs primarily through transpiration as performed by the plants.

4. CONCLUSION

Fresh Fruit Bunches (FFB) of oil palm are processed into palm oil or Crude Palm Oil (CPO), producing a by-product in the form of Empty Fruit Bunch (EFB) waste. EFB waste is further processed into organic fertilizer and organic mulch. The process of converting oil palm EFB waste into organic fertilizer and mulch is divided into two stages: 1**.** Processing Fresh Fruit Bunches (FFB) into Empty Fruit Bunch (EFB) Waste**,** which includes: a) Weighing stage, b) Sorting stage, c) Loading ramp stage, d) Sterilization stage, e) Threshing stage, and f) Empty bunch hooper stage. 2. Converting EFB Waste into Organic Fertilizer and Mulch**.** The production process for organic fertilizer and mulch occurs naturally and conventionally. EFB waste is used as both organic fertilizer and mulch by spreading it over the soil around the oil palm plants. The decomposition process into organic fertilizer takes approximately one year.

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