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MINI REVIEW

A review on the potential of empty fruit bunch (EFB) compost as growing medium for oil palm seedling production

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Abstract

The oil palm industry is among the important sectors in Malaysia. The productions of palm oil keep increasing year by year due to high demand from other countries, generating an abundance of wastes from the field and the mill. These wastes may significantly affect the environment. Composting is one of the methods to reduce the volume of waste. The compost material is widely used especially in agriculture activities due to its properties which have been enhanced during the composting process. Empty fruit bunch (EFB) compost mostly returns to the soil as mulch to conserve soil moisture and acts as organic fertilizer since it contains high nutrients needed by the plant. Currently, the depletion of fertile soil leads to less availability of growing medium, especially in the nursery. The properties of the growing medium are important to ensure better root development of seedlings and subsequently affect the overall plant growth. Therefore, numerous studies have been conducted to identify the suitable growing medium as a substitute for topsoil which is currently limited to raising seedlings in the nursery. This review examines the current methods of composting EFB and provides summarized research information on the effect of EFB compost on oil palm seedling growth. The oil palm wastes that are properly managed could produce value-added by-products and promotes sustainable agriculture practices.

1. Introduction

The effects of tropical climate and optimum soil conditions in Malaysia lead to the high production of oil palms in this country. In Malaysia, the total area of oil palm is approximately 5.9 million hectares and the production of crude palm oil (CPO) and palm kernel oil (PKO) in 2019 were 19.86 million tonnes and 2.32 tonnes, respectively (Parveez *et al.,* 2020). The substantial of this industry leads to the great formation of oil palm biomass particularly empty fruit bunch (EFB) and palm oil mill effluent (POME). According to Hau *et al*. (2020), EFB has generated about 19 million tonnes annually. A tonne of FFB produces about 23% of EFB (Baharuddin *et al.,* 2010) and every tonne of FFB processed produces approximately 0.6 to 0.87 m^3 liquid wastes or 2.4 to 3.7 tonnes of liquid wastes per one tonne of palm oil produced with biological oxygen demand (BOD) of 20,000–25,000 mg/L, chemical oxygen demand (COD) of 40,000–50,000 mg/L and pH 3.8–4.5 (Trisakti *et al.,* 2015). Nevertheless, these wastes contain a substantial amount of macro- and micronutrients which are essential elements for plant growth.

Previously, most of the EFB that were produced from palm oil mills were used for boiler fuel, incineration and returned to the plantation as mulching. However, the high moisture content of EFB made it less suitable for boiler fuel, and the transformation of EFB through burning to produce fertilizers is prohibited by the Department of Environment (DOE). The burning of EFB is prohibited because it affects the environment negatively by polluting the air (Embrandiri *et al.,* 2013). Besides, the application of mulching using EFB creates issues of soil toxicity and eutrophication (Lyana *et al*., 2019). Although POME is treated conventionally through an open pond, it causes a significant impact on the environment due to the enormous release of greenhouse gases (Abdullah *et al.,* 2013). To reduce the issues of these wastes the composting is the best option.

The composting product derived from palm oil processing is widely used in the agriculture industry. Most EFB composts are used as mulches and biofertilizers. However, there are several studies conducted to identify the suitability of EFB compost as a growing medium especially for oil palm seedlings since

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the current growth media is limited. Topsoil is conventionally used as a growing medium due to its physicochemical properties that provide a conducive environment for root development. However, topsoil is currently limited due to Malaysian soil being acidic and requiring a lot of fertilizer to support plant growth (Salisu *et al.,* 2016). The high rainfall environments lead to soil acidification where the basic cations Ca, Mg, K, Na has leached away and resulted in the accumulation of iron and aluminium oxides and this condition lead to unfertile soil which requires more fertilizer application to increase crop production. Furthermore, the use of soil could cause incidence associated with soil-borne diseases (Salisu *et al*., 2016). Fungi is the most common soil-borne pathogens that cause roots rot which disrupts the uptake and flow of water and nutrients through the plant. Some common root rot fungi include Cylindrocladium, Pythium, Phytophthora, and Rhizoctonia. Therefore, there is a need for an alternative growing medium to sustain the production of oil palms.

2. Composting and enrichment of EFB compost properties

The direct use of agricultural wastes is not suitable for land and agricultural productions because the structures of these wastes are unknown and they contain contaminants such as pathogens, weed seeds, heavy metals, and unpleasant odours (Vakili *et al.,* 2015). Thus, composting is a feasible method to ensure the wastes are safe. Composting is a process of biomass conversion into better quality products that can be used safely. Furthermore, it offers extremely useful, manageable and environmentally friendly products. The compost materials help to enhance the properties of soil physically, chemically and biologically. The application of compost promotes microbial activities in the soil which resulted in to increase pore space of the soil. The chemical properties are enhanced through the increase of the cation exchange capacity (CEC) that influences the ability of soil to hold onto essential nutrients for plant growth. Currently, the wastes, particularly EFB and POME, that are discharged from palm oil mills in Malaysia are converted into compost. Moreover, composting of EFB can reduce the total volume of EFB up to 50–75% from the palm oil mill (Hoe *et al.,* 2016). Thus, composting can manage the waste produced from the mill and could generate income from the commercialization of the compost produced from the agricultural sector (Then *et al.,* 2016).

Composting EFB requires a long period due to its recalcitrant structure that is composed of lignin, cellulose and hemicelluloses, as well as other minor elements. Generally, it takes 60–90 days to achieve the maturity stage. However, this process could be intensified with the inoculation of exhibit cellulolytic and hemicellulolytic microbes that can be found from POME anaerobic sludge. There are 27 strains of indigenous microbes available to complete the composting process in 40 days (Huzairi *et al*., 2013). Also, the final properties of this compost material show low macronutrients and the enhancement of the compost is improved through the addition of artificial N, P and K elements (Hau *et al.,* 2020). The addition of these macronutrients will enhance the chemical properties of EFB compost and thus promote the growth of oil palm seedlings. However, the inoculations of microbes onto EFB compost only benefit the plant in short term and cause an unfavourable soil environment that may affect microbial activities.

Therefore, many studies have been carried out to enhance the final properties of EFB compost and afterwards increase the value of oil palm wastes. According to Adam *et al.* (2016), the addition of oil palm decanter cake (OPDC) together with EFB and POME (1:3:0.2) increase the contents of N, P and K (N 1.57%, P 0.21%, K 0.65%). The OPDC contains a high amount of N which helps to speed up the composting process within 10 weeks at the lowest CN ratio (23.4) compared to compost material without having the OPDC. A similar finding also has been assessed by Yahya *et al.* (2010) on the mixtures of decanter cake slurry from palm oil mill +EFB +POME which found increased contents of nitrogen (+46.4%), phosphorus (+17.9%), potassium (+17.7%) and calcium (+23.1%). The increased nutrient content of EFB compost particularly macronutrients encourages a favourable environment for oil palm seedling growth. Meanwhile, the addition of cow dung into EFB (2:1) revealed better compost quality with increased element contents of phosphorus (+390.54%); calcium (+373.17%); magnesium (+370.93%) and potassium (+153.66%) (Lim *et al.*, 2015).

The mixing of EFB with livestock manures also can enhance the microbiological and biochemical variations during the composting. Thambirajah *et al.* (1995) carried out a study on the composting EFB with the addition of goat dung, cow dung, and chicken manure. The study found the mesophilic and the thermophilic bacteria were active, whereas fungal activity was decreased within the peak heating period which could minimize the incidence of diseases derived from the compost-based planting medium. Moreover, the inoculation of effective microbes (EM) into the compost materials also has been studied where the EM acts as an enhancer of the compost material. The inoculation of EM has slightly improved the content of minerals such as Mg, K, Ca, and B, as well as a key metabolite, 5-aminolevulinic acid for plant growth at the maturity stage of compost (Lim *et al*., 2015) which make the compost suitable for oil palm seedling production.

Despite composting the EFB by mixing it with other organic matters, there is a study conducted by Trisakti *et al.* (2017) in which the EFB was mixed with activated liquid organic fertilizer (ALOF). This material increases the nutrient value of the compost and acts as a microbial source that can enhance the composting process. ALOF can be obtained from a methanogenic anaerobic digester that produces treated biogas effluent that keeps the moisture of the compost. The final compost treated with ALOF shows good characteristics of compost where it can be used as liming material (pH 9.0) and acts as biofertilizer (CN ratio 12.15%, P 0.58%, and K 0. 95%). The good pH of compost material promotes root growth and increased nutrient uptake.

Recently, another method for composting EFB that was being studied was vermicomposting. Vermicomposting is a conversion process of organic waste through interactions with earthworms and microorganisms which can reduce the composting period (Singh *et al.,* 2020). Vermicomposting not only accelerates the composting process but can also increase the CEC through the formation of fine fragmentation as compared to the conventional method which permits more efficient nutrient uptake by the plant and promotes better aeration. The most commonly found essential elements in vermicompost are N, P, K and Mg. Besides that, the final product (vermicast) has the potential to hold nutrients for a longer period than the conventional compost (Hau *et al.,* 2020). Thus, enhancement of EFB compost properties through vermicompost show the final properties of EFB compost provide an optimum planting medium, especially for oil palm seedling. A study on vermicompost produced from the mixture of EFB +POME with fishmeal (FM) and bonemeal (BM) showed increasing nutritional value. The N (+18 to 62%), the P (+125 to 906%) and the K (+262 to 294%) contents were drastically increased. The maturity can be achieved in about 40–52 days with a CN ratio of less than 20 (Hau *et al.,* 2020).

3. The effect of EFB compost as a growth medium

The growing medium is crucially important to produce high-quality seedlings. Conventional topsoil is used as a growing medium to raise oil palm seedlings because the topsoil contains high nutrients with good physical properties that can support the growth of the seedling. However, this practice needs to reassess since the topsoil is currently a limited source for the future of the oil palm industry. To supply oil palm seedling for 136 palms per hectare, it requires about 0.143 hectares of topsoil at the depth of 15 cm for the pre-nursery and another 1.60 hectares of topsoil at the same depth for the main nursery. Therefore, the total area of 1742 ha at the depth of 15 cm topsoil needs to be supplied for nursery operations (Suryanto and Wachjar, 2015). High production of palm oil in this country causes depletion of topsoil and degradation of the area from which it is collected. Moreover, the use of topsoil is heavy to handle especially during the transplanting process from nursery to field (Shahkhirat *et al.,* 2016). Hashim *et al.* (1987) stated that the growth medium such as peat, dried effluent, and coir dust is suitable to be used for raising oil palm seedlings in the nursery (Shahkhirat *et al.*, 2016). The use of organic substrate for plant growth media is the best option since it is readily available, less expensive, and conserves the environment. Many positive results have been recorded from previous studies on the effects of organic material in raising oil palm seedlings.

3.1 Oil palm seedling growth

The enrichment of the EFB compost properties through the addition of several organic substances and inoculation of microbes during composting lead to the utilization of EFB compost as soil substitutes for raising oil palm seedlings in the nursery. Suryanto and Wachjar (2015) discovered the use of compost and vermicompost which can substitute topsoil for raising oil palm seedlings in double stage nurseries since the compost has a nutrient grade of N (1.32%), P (0.49%) and K (0.06%), while vermicompost has N (1.05%), P (0.58%) and K (0.03%). The application of compost showed better morphological and physiological growth although it is not significantly different with vermicompost treatment. Studies by Rovica *et al.* (2018), shows the application of EFB compost mixture as a soil amendment for oil palm seedling significantly improved physicochemical properties of the polybag medium and root development of the seedling. The high root volume of the seedling will increase the survival rate after field planting because the high volume root system results in greater capability for absorption and transportation of water, thus improving the plant's ability to handle environmental stress (Jacobs *et al.,* 2005). In addition, the high percentage of oil palm compost as a growing medium could reduce the heavy structure and compaction of the soil. Soil compaction could have caused root restriction that may cause poor plant vegetative growth. As assessed by Seman *et al.* (2018), a compost-based planting medium has the potential to influence seedling as an alternative growth medium compared to the soils used in oil palm nurseries.

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3.2 Plant nutrient uptake

The addition of EFB compost increased nutrient availability and retention in the growing medium. The surface of organic matter-like compost is rich in negative functionalities such as phenolic, carboxylic, carbonyl, and alcohol which serve as exchange sites that ultimately increased the CEC of growth media and subsequently promote efficient nutrient usage (Palanivell *et al.,* 2013). As assessed by Rosenani *et al.* (2016) the nutrient uptakes (N, P, K, Mg, Ca, Fe, Zn and Cu) are high for oil palm seedlings grown in 60–100% of compost media. Macronutrients (particularly N, P and K) played a vital role, especially in the growth of young oil palm. According to Rovica *et al.* (2018), oil palm shoot biomass was positively correlated with N and K uptake. The N and K are the essential nutrients for the improvement of vegetative dry matter production and leaf area index of young oil palm (Corley and Mok, 1972).

Furthermore, the mixture of EFB compost with topsoil showed positive effects of improving physical properties, exchange and buffering capacities, and becoming nutrient sources for plant uptake. These properties lead to an increase in the seedling dry matter weight up to 71% at the main nursery stage as the composted EFB and POME were applied at the rate of 150 g per polybag in a study by Aisueni and Omoti (2001) as cited by (Rosenani *et al.,* 2016). However, the rate of compost needs to properly be identified because according to Zhang *et al.* (2013), the application of compost for more than 70% causes a reduction in plant growth and root morphology. This could be attributed to the presence of phytotoxic substances and negative changes in the chemical and the physical properties of growth media (Zhang *et al.,* 2013; Rosenani *et al.,* 2016). On the other hand, according to Rosenani *et al.* (2016), oil palm seedlings in the pre-nursery stage showed the best growth performance with the application of 72% of oil palm compost mixed with topsoil.

According to Hastuti and Rohmiyati (2020), the application of EFB compost that was inoculated with phosphate solubilizing bacteria (PSB) on latosols soil has increased the height of oil palm seedlings in the pre-nursery. The addition of organic matter to the soil will produce chelation of polyvalent cations by organic acids and other decay products that caused increased P availability in soil. The inoculation of PSB also can produce plant growth regulators such as indole acetic acid (IAA) and gibberellin (GA) that could promote oil palm seedling growth (Hastuti and Rohmiyati, 2020). In addition, the high availability of P through the inoculation of PSB on EFB compost could reduce the cost of fertilizer for nursery operations. It was supported by Siregar *et al.* (2002), the combination of EFB compost with topsoil can substitute the conventional manuring program in the main nursery.

4. Conclusion

The various method of composting EFB shows the EFB compost can be used as a planting medium for oil palm seedling. The enhancement of its physicochemical properties especially the nutrients content indicate that these materials can fulfil the requirements of a suitable planting medium for oil palm seedling productions. EFB compost also could be used as a biofertilizer which would reduce the manuring cost in oil palm nurseries. Furthermore, the use of EFB compost provides a lightweight planting medium which is important for handling and transportation. The lightweight planting medium would reduce the burden for workers during field panting operation and increase palm distribution time during planting or replanting exercise. Despite this, oil palm waste management is essential to minimize environmental impact and to ensure a sustainable palm oil industry. The utilization of EFB in large volumes could manage these major palm oil mill wastes and can also reduce the cost and subsequently increase the income. Research and innovations together with technology are required to ensure the final properties of EFB compost can be used for plant growth media to ensure the source of growing media for oil palm seedlings are available and accessible for sustaining the palm oil industry in Malaysia.

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