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Review

Critical evaluation of oil palm fresh fruit bunch solid wastes as soil amendments: Prospects and challenges

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ABSTRACT

Sustainable land use has been identified as one way of tackling challenges related to climate change, population expansion, food crisis and environmental pollution. Disposal of oil palm fresh fruit bunch (FFB) solid wastes is becoming a challenge with an increased demand and production of palm oil. Whilst this poses a challenge, it could be turned into an opportunity by utilising it as a resource and fully valorise it to meet soil and crop demands. This review presents the potentials of FFB solid wastes, which include empty fruit bunch (EFB), mesocarp fibre (MF), palm kernel shell (PKS), as soil ameliorants. The major findings are the following: 1) pyrolysis, gasification, combustion, and composting are processes that can enhance the value of FFB solid wastes. These processes lead to new products including biochar, ash, and compost, which are valuable resources that can be used for soil improvement. 2) The application of EFB mulch, ash from EFB, MF and PKS, biochar from EFB, and PKS, and compost of EFB, and MF led to improvement in soil physico-chemical properties, and growth and performance of sweet corn, mushroom, oil palm, sweet potato, cauliflower plant, banana, maize, cocoa, cassava, eggplants, and pepper. However, reports show that EFB compost and ash led to decrease in growth and performance of okra. Therefore, the use of appropriate conversion technology for FFB solid wastes as soil ameliorants can significantly improve crop yield and soil properties, reduce environmental pollution, and more importantly increase income of oil mill processors and savings for farmers.

1. Introduction

Agricultural productivity and land conservation are important for the sustainability of humanity. With an increasing demand for food due to increasing population, an integrated sustainable approach needs to be adopted to ensure that agricultural production does not impinge negatively on land resources. To ensure there is continuous supply of food and fibre without depleting the land resources, one approach to replenish nutrients can be through the application of organic amendments. Lack of resources limit soil conservation practices and therefore efforts are being made towards deriving greater values from available organic materials. Organic amendments have gained interest due to the high cost of inorganic fertilisers and the adverse effects of its continuous usage on soil. However, inefficient use of organic amendments can pose significant environmental challenges such as eutrophication of water bodies and leachate affecting groundwater. Applying these amendments to the soil in an optimum manner can result in an increase in soil organic matter, which improves soil fertility and minimises soil degradation (Rickson et al., 2015).

African oil palm (*Elaeis guineensis*) is believed to originate from West Africa and today is widely grown in most parts of West and Central Africa, Southeast Asia, and South America. Oil palm is a single stemmed tree and can grow to a height of more than 30 m (Ibitoye and Onje, 2013; Jagustyn et al., 2013). The fruit bunch can weigh up to 25 kg and contain as much as 1000 fruits (Ibitoye and Onje, 2013; Jagustyn et al., 2013). The oil palm tree is the major source of plant oil in the tropical region.

Palm oil is produced by processing oil palm fresh fruit bunch (FFB), which leads to the generation of FFB solid wastes. Notable FFB solid wastes are empty fruit bunch (EFB), mesocarp fibre (MF), and palm kernel shell (PKS) while palm oil mill effluent is the liquid wastes (Fig. 1). Other residues and/by-products processed from FFB solid wastes are in the form of ash, biochar, and compost. The major producers of palm oil are Indonesia, Malaysia, Thailand, Colombia and Nigeria according to Index mundi (2017), contributing 92% of global production (Fig. 2). An estimated 1.65 million hectares of oil palm is spread over Nigeria (Olagunju, 2008), while there are over 4 million and 7 million hectares of oil palm in Malaysia and Indonesia,

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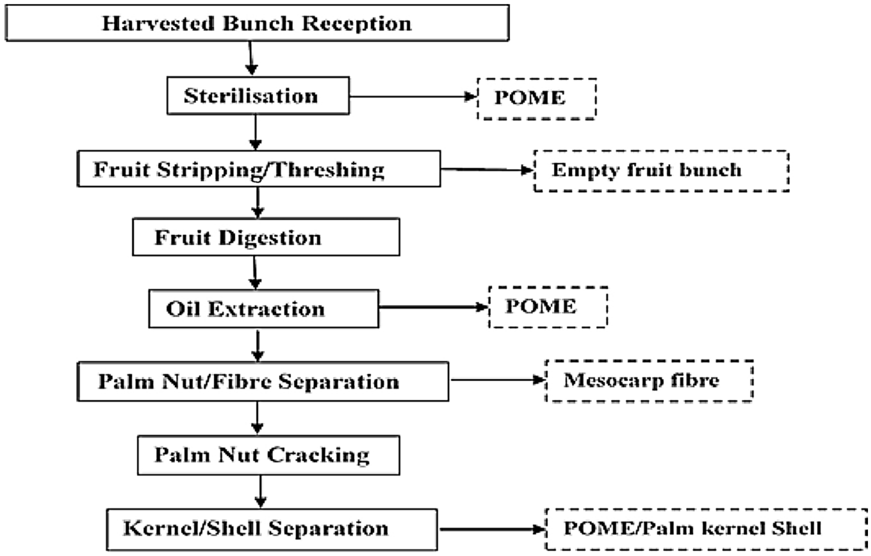

Fig. 1. Flow chart of fresh fruit bunch processing showing points of generation of wastes. Solid boxes are the process, while dashed boxes represent wastes. POME - palm oil mill effluent.

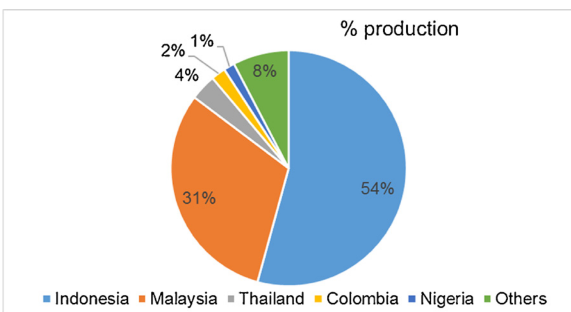

Fig. 2. Global percentage of palm oil production.
(Source: Index Mundi, 2017).

respectively (Sulaiman et al., 2011). Anyaoha et al. (2018) reported that the total FFB solid wastes produced in 2014 was 75 million tonnes, and that the figure is equivalent to 23 million tonnes of EFB, 21 million tonnes of MF, and 7.5 million tonnes of PKS.

The FFB solid wastes are used as fuel in palm oil mills to generate steam, which enables the palm oil mills to be self-sufficient in energy (Yusoff, 2006); however, more of the wastes are generated than required in the palm oil mills. Therefore, proper utilisation of the FFB wastes remains a challenge for palm oil millers and local authorities.

This paper aims to present a critical evaluation of the value of FFB solid waste streams (EFB, MF, PKS, ash, biochar and compost) and their benefits for crop performance and soil quality improvement, when used as organic amendments. Specifically, the following will be reviewed: (i) the current progress on the soil applications of FFB solid waste by-products (ash, biochar, and compost) derived from thermal and biological conversions of EFB, MF, and PKS, and (ii) the agronomical and environmental impacts of FFB solid waste streams utilisation, providing bases for strategic development needs.

2. Fresh fruit bunch solid waste streams

There are variations in the physical and chemical characteristics of FFB solid wastes. Apart from the potential differences due to geography and the soil where the trees are grown, oil palm tree differs due to the thickness of the shells (varieties), and on the quality of the FFB. Dura variety is known for its thick shell and thin mesocarp, Pisifera variety is known to be shell-less, while Tenera variety has a thicker mesocarp and thinner shell (Asadullah et al., 2014). In Nigeria, most palm oil mills process a mixture of the three varieties. Higher quality FFB produces relatively more fruits compared to the size of the EFB, a tree can produce varying bunch (high and low-quality). These variations influence the weight of EFB, PKS, and MF per FFB. Tables 1–3 summarise the characteristics of EFB, MF and PKS, respectively.

EFB is generated when the fruits are removed from the FFB. It can appear in different forms depending on how the FFB is processed, which differs particularly in Nigeria with the generation of empty fruit spikelet (EFS), and bunch stalk (BS) separately by the subsistence (traditional processing) palm oil millers (Anyaoha et al., 2018). The chaff is the additional part of the EFB. The chaff is found at the base where each fruit is attached to the spikelet and tends to separate itself from the spikelet when dry. The chaff comprises of about 0.9–2.4 % of FFB (Ohimain et al., 2013). The EFB is generated at the palm oil mills with very high moisture content of up to 60% (Tabi et al., 2008). Relative to MF, and PKS, EFB has a very low bulk density, which makes its transportation difficult (Tables 1–3).

The MF or palm press fibre results from the oil bearing mesocarp after the extraction of oil and separation of the pulp (palm nut/mesocarp fibre mixture). The oil is extracted by washing the pulp with steam or by pressing. The MF makes up about 14–28.1 % of FFB (Ohimain et al., 2013; Omar et al., 2011; Sulaiman and Abdullah, 2011).

The palm nut or the endocarp is the hard part of the oil palm fruit covering the oil-bearing palm kernel. The palm nut when cracked takes varying shapes and sizes because of the cracking force and the resulting product is called PKS. When compared to EFB and MF, PKS has lower moisture content, and higher lignin and bulk density (Tables 1–3).

The availability of MF and PKS as better biomass fuels makes the application of EFB to oil palm plantations the best option. The BS (82.6%) of higher moisture content than that of the EFS (57.5%) according to Omar et al. (2011) limits the use of EFB as fuel. The Conversion FFB solid waste streams into forms ready for use as soil ameliorants is as important as the availability of the wastes. Other than direct application, pyrolysis, gasification, combustion, and composting are well-researched technologies of valorising FFB solid wastes. These technologies lead to the production of ash, biochar, and compost, which are important soil amendments that will be discussed in the following sections.