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Review

Production, utilization and acceptability of organic fertilizers using palms and shea tree as sources of biomass

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This document contains relevant information on biomass generation, utilization for the production of organic fertilizers and their alternative uses with respect to The Nigerian Institute for Oil Plam Research (NIFOR) mandate crops. The production of organic amendments using empty fruit bunches from the Oil palm *Elaeis guineensis* and its utilization in soil fertility management is well established. On an average, for every tonne of fresh fruit bunches (FFB) processed wastes of 230 to 250 kg empty fruit bunch (EFB) and 130 to 150 kg of fiber is produced. This large amount of biomass/waste can be successfully converted to fertilizer through the process of composting and can then be ploughed back into the soil. The palm oil mill effluent (POME) is also available, which in more recent times is being used as a soil conditioner and a source of bio fertilizers. Composted coir pith obtained from coconut *Cocos nucifera* husk is found to be rich in plant nutrients with nitrogen, phosphorus and potassium percentage values of 1.24, 0.06 and 1.20, respectively among other required plant nutrient. Percentage nutrient values for composted date palm *Phoenix dactylifera* biomass are also available in this paper. These mandate crop posses several alternative uses which makes them useful to the food and feed industry as well as oleo chemical, fuel, building and construction, pharmaceutical and confectionary industries. The information presented strongly suggests and confirms that the various biomass and residue produced by the palms and shea tree industry can be fully harnessed for organic fertilizer (manure) production even for commercial purposes by and for farmers in order to increase crop production.

Key words: Organic fertilizer, composting, biomass, alternative uses.

INTRODUCTION

Fertilizers are the most important input that ensures optimum crop production and are broadly classified into chemical and organic fertilizers. The use of organic fertilizer dates back to mans early farming activities. Modern research on the use of organic manure for the production of arables in Nigeria is shown in the pioneer work of Hartley and Greenwood (1933). The availability and affordability of chemical and high analysis fertilizers to the average farmer is less than optimal hence the need to source for locally available compostable organic materials. More recently, organic farming has become preferable especially for vegetable production particularly in the advanced countries. Research has shown that organically produced foods/ crops are healthier for consumption and safer for the environment. Hence, there is a rapidly growing demand for organic fertilizers that

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have levels of macro and micro nutrients which are comparable to that of inorganic fertilizers when applied at the same dosages and intensity.

The development of organic fertilizer entirely from naturally derived sources with the required specifications is for purpose of satisfying this growing demand in the agricultural industry. Organic fertilizers are sources of soil nutrients produced from organic materials usually of plant and /or animal origin. These fertilizers are manufactured using organic substances which are bio-degradable. These organic substances are further decomposed and broken into smaller and soluble particles by numerous microorganisms. Some advantages of organic fertilizers include: Replenish the soil, keeps soil friable, promotes beneficial soil life, increases crop yield and grows larger plant, prevents hardpan, benefit environment by recycling and reducing waste, minimize green house gas emission, protects certain crops from disease, are safe and cheaper than chemical fertilizers as it can be locally prepared.

Bio fertilizers simply mean “living fertilizers”. Unlike the organic fertilizers, bio fertilizers are a mixture of beneficial microbes such as bacteria and fungi which have been reported to enhance the yield of crops. These microbes include soil inoculants which are preparations of the nitrogen fixing bacterium rhizobium for inoculating legume seeds (Odeyemi, 1991). The use of vesicular arbuscular mycorrhiza (VAM) has been shown to increase crop yield when used with woody leguminous prunnings (Rafiu-Adio et al., 2000). Some benefits of bio fertilizers include: Increase crop yield by 20 to 30%, replace chemical N and P by 25%, stimulates plant growth, activate soil biologically (Toyota and Kuninaga, 2006), restores natural fertility and provides protection against drought and some soil borne diseases. The following are types of bio fertilizers: For nitrogen supply; *Rhizobium* for legume crops, *Azotobacter*/*Azospirillum* for non legume crops, *Acetobacter* for sugarcane only and BGA and Azolla for low land paddy. For Phosphorous: *Phosphatika* for all crops to be applied with *Rhizobium*, *Azotobacter*, *Azospirillum* and *Acetobacter*; For enriched compost, cellulolytic fungal culture and *Phosphotika* and *Azotobacter* culture (Singh and Amberger, 1991).

Organic manures/fertilizers are obtained from the composting/processing of organic materials. These materials could be: Plant material, animal material, urban/industrial material (Municipal Wastes), night soil, mineral organic materials and bacterial/ fungal materials (Chude and Uzoigwe, 2001).

NIFOR MANDATE CROPS–SOURCE OF BIOMASS FOR ORGANIC FERTILIZER PRODUCTION

The Nigerian Institute for Oil Plam Research (NIFOR) has five mandate crops. These include: Oil palm (*Elaeis guineensis*), Coconut palm (*Cocos nucifera*), Date Palm (*Phoenix dactylifera*), Raphia Palm (*Raphia hookeri*) and the Shea tree (*Vitellaria paradoxa*). These tree crops produce biomass which can be used for the production of organic fertilizer as well as other alternative uses. This document shows the availability of biomass of these mandate crops and possible uses as organic fertilizer as well as alternative uses.

Oil palm (*E. guineensis*)

Cultivation of the oil palm (*E. guineensis* Jacq.) has expanded tremendously in recent years such that it is now second only to soybean as a major source of the world supply of oils and fats. From its home in West Africa, the oil palm (*E. guineensis* Jacq.) has spread throughout the tropics and is now grown in 16 or more countries (Basri et al., 2003). However, the major centre of production is in South East Asia (SEA) with Malaysia and Indonesia together accounting for around 83% of world palm oil production in 2001. Presently, Southeast Asia is the dominant region of production with Malaysia being the leading producer and exporter of palm oil. In spite of the huge production, the oil consists of only about 10% of the total biomass produced in the plantation. The remainder consists of huge amount of oil palm wastes (biomass) such as oil palm shells, mesocarp fibers, empty fruit bunch (from the mills), oil palm fronds and oil palm trunk (Plate 1). At the palm oil mill, the sterilized fresh fruit bunches (Plate 2) goes through a threshing process to separate the fruit from the nuts. The emptied fruit bunch mainly consists of a main stalk (20 to 25%) and numerous spikelets (75 to 80%) with sharp spines at their tips. For the years of 2007 to 2020, it is projected that an average of 2.856 million tones (dry basis) of empty fruit bunches will be produced per year (ADB, 2006). Oil palm fronds are collected during pruning and replanting activities. The availability of fronds during the pruning activity was calculated using an estimate of 10.4 tonnes ha^{-1}, which currently gives an average of 6.97 million tonnes per year. Meanwhile, it was estimated that an average of 54.43 million tonnes per year of oil palm fronds will be available during the replanting process in the years 2007 to 2020. The Oil palm tree normally passes their economic age, on an average after 25 years. During replanting, the bole length of felled palm trunk is in the range of 7 to 13 m, with a diameter of 45 to 65 cm, measured at breast height. The area due for replanting has to be multiplied with the average number of 134 palms ha^{-1}, or in volume of 1.638 m^3ha^{-1}. About 53.87% (dry weight) of fiber bundles can be extracted from a trunk, with the remaining parts being the bark and parenchyma tissues which contribute to 14.45 and 31.68% of the dry weight of the trunk respectively (ADB, 2006).

In the processing of palm oil, the main by-product and wastes produced are empty fruit bunches (EFB), palm oil

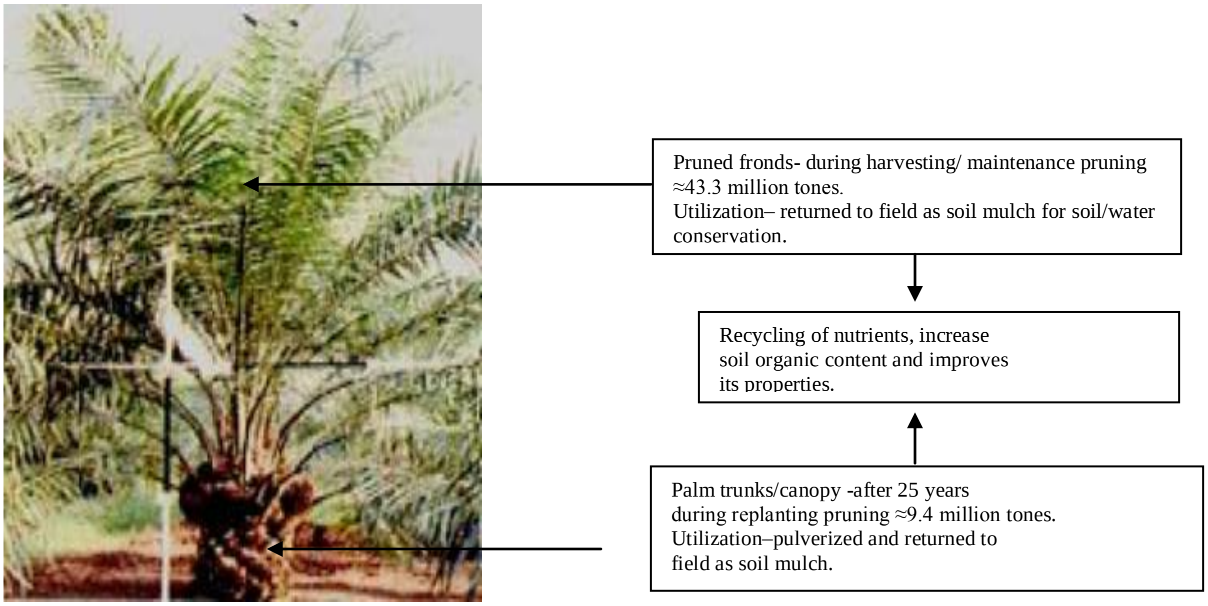

Plate 1. An oil palm showing output of recyclable biomass of oil palm in Malaysia, 2006.

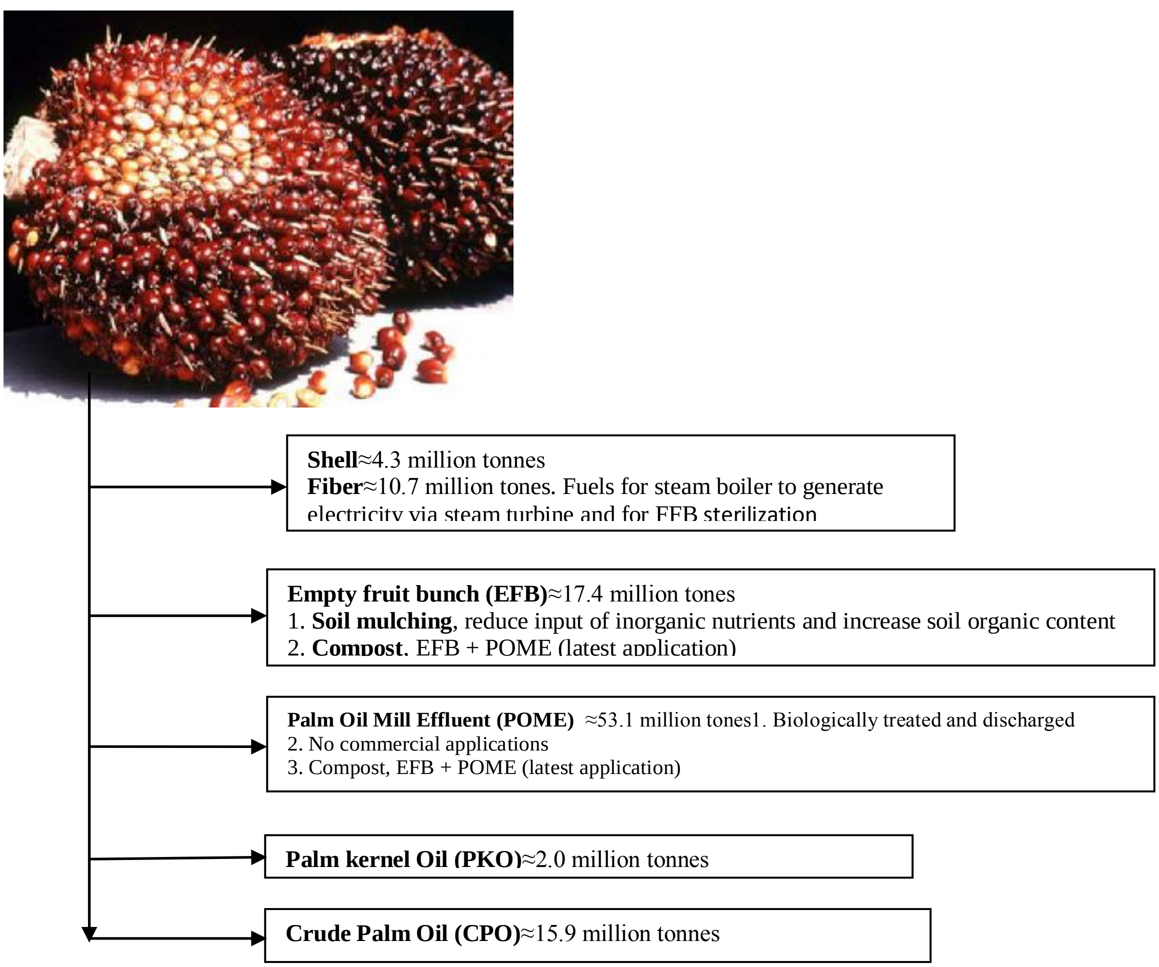

Plate 2. Total fresh fruit bunch processed≈79.3 million tones.

Figure 1. Flow chart of the MDF manufacturing and samples of MDF.

Plate 3. Plywood from oil palm trunk.

mill effluent (POME), mesocarp fiber and palm kernel shell/ cake residue (Yusoff, 2006).

On an average, for every tonne of fresh fruit bunches (FFB) processed, wastes of 230 to 250 kg empty fruit bunch (EFB), 130 to 150 kg of fiber, 60 to 65 kg of shell and 55 to 60 kg of kernel are produced (Karen, 2008). Currently, 15 million tonnes of EFB are generated annually from Malaysian palm oil industry (Rahman et al., 2006). Therefore, EFB as lignocelluloses, afford a renewable biomass and low-cost raw material for the production of high valued products such as polylactate, ethanol and compost.

The following are alternative uses of oil palm biomass: Medium density fiberboard (MDF) production. Malaysia is one of the top five exporters of MDF in the world. Our total production capacity exceeds one million cubic meters per year. Presently, most of the major producers use rubberwoods as the raw material. With the decline in the price of latex, interest in rubber is only about 1.2 to 1.4 million hectares, which is approximately half of its original size slightly over a decade ago. As such, it is envisaged that the supply of rubberwood for MDF production would not be sufficient to cater for the huge demand. The oil palm biomass has been tested in the laboratory and pilot scale at MPOB and elsewhere to be suitable as substitutes for rubberwood as raw materials for MDF production (Figure 1).

Plywood is also produced from oil palm trunks (Plate 3). A study was made to manufacture oil palm plywood consisting of 100% oil palm for the core, and the tropical hardwood for face and back veneer. Oil palm trunks used for manufacturing plywood were collected during replanting. Specific cutter gap and rotation during the peeling process are vital for processing the oil palm trunk, due to its inconsistence of vascular bundles arrangement. In general, the mechanical strength properties of oil palm trunk plywood meet the strength requirements as stipulated in the Japanese - Standard Method (JAS 233:2003).

Manufacturing of flat particleboard from oil palm biomass was envisaged a long time ago and the research started over 20 years ago with a few companies attempting to manufacture particleboard especially from EFB. Such end products are school and office desks and chairs, table tops and cabinets. The specialty of the flat particleboard produced from EFB using this process is that it has high screw withdrawal strength that is essential for the manufacture of quality furniture. Oil palm is also used as a delicacy meal. Palm heart has become an exotic mass product mainly used as salad ingredient especially in Europe. Normally, in our country, the source of oil palm heart is from coconut tree, but now oil palm heart has been introduced, which can be collected during replanting of oil palm tree. Oil palm hearts are slender, ivory-colored, delicately flavored, quite expensive and normally can be recovered at around 12 to 15 kg. A technology on mechanizing the extraction of the oil palm hearts had been developed, which consist of a mobile tractor system and attached with an auger. Activated carbon and advanced carbon products are also obtained from the oil palm tree (Plate 4). Oil palm biomass contains about 40 to 45% (wet basis) of carbon content, which is suitable for the preparation of carbon products.

Density = 0.95 - 1.30 g /cm^3
Porosity surface area (S_{BET}) = 680 - 1123 m^2/g
Micropore surface area (S_{MICRO}) = 360 - 1016 m^2/g

Plate 4. High porosity carbon powder and carbon pellets from EFB and the porosity characteristics.

Plate 5. A coconut palm, Nigerian Institute for Oil Palm Research (NIFOR), Nigeria.

The research and development for the preparation of advanced carbon products from oil palm empty fruit bunch (EFB) had been embarked since 2003, and with recent technology, MPOB successfully developed a process on preparation of carbon pre-cursors for the production of carbon electrode, electrical carbon brushes and Molecular Sieve Carbon (MSC) for gas filtration from EFB. Chemical treatment, carbonization and physical activation processes were applied to the carbon pre-cursors for the preparation of high porosity activated carbon powder and carbon pellets.

Coconut palm (*C. nucifera*)

Available coconut palm biomass include: Palm fronds, trunk, husk, coconut shell. The fronds and husk are easily compostable biomass of the coconut palm and have been used in the production of organic manure. The largest by products of coconut is coconut husk from which coir fibre is extracted. This extraction process generates a large quantity of dusty material called coir dust or coir pith. Large quantity of coir waste of about 7.5 million tones is available annually form coir industries in India (Plate 14). In Tamil Nadu state alone 5 lakh tons of coir dust is available. Coir pith has gained importance owing to its properties for use as a growth medium in Horticulture. Because of a wider carbon and nitrogen ratio and lower biodegradability due to high lignin content, coir pith is still not considered as a good carbon source for use in agriculture. Coir pith is composted to reduce the wider C: N ratio, reduce the lignin and cellulose content and also to increase the manorial value of pith (Table 2). Composting of coir pith reduces its bulkiness and converts plant nutrients to the available form. Every part of the coconut plant (Plate 5) has its value to humans; there are 20 more uses of coconut. These include as (1) tableware- the shell of a coconut can be used to make tableware such as bowls, serving tray, spoon or ladle; (2) fashion accessories-the coconut shell can also be carved out to make fashion accessories like necklaces, bangles, pendants, earrings and so on. In fact, the Hawaiians use coconut shell to make the buttons for their Hawaiian shirts; (3) furniture- the trunk of the coconut palm can be turned into furniture; (4) fuel source- the coconut shell and coconut husks are good sources of fuel; (5) brooms- The midribs of the coconut leaves are usually bundled and tied up with strings to become brooms; (6) barbecue skewers- the midribs or the coconut leaves can also be used as barbecue skewers; (7) ropes- the fiber material of coconut husk, which is also known as coir, can be used to make ropes; (8) brushes- the fiber material of coconut husk can also be used to make brushes which are usually used to scrub floors; (9) woven products- the coconut leaves can be woven to create products like baskets, bags and mats; (10) musical instruments- halved coconut shells are knocked together to make up rhythms and beats. The coconut shells are also used to make the base of musical instruments such as the Chinese “ban-hu” and “yea-hu”; (11) roof- the dried coconut leaves are used to make roofing materials for tropical huts in the ancient times. However, nowadays roof made up of coconut leaves is still being used for chalets at tourist attractions; (12) hair oil- coconut oil is regularly used as natural hair oil by people in some parts of the world like in India and in Southeast Asia. It is believed that coconut oil can promote healthy hair growth and also to treat hair infected by lice; (13) bridge- the palm wood of the coconut trunk is also used as a bridge to cross river in the olden days; (14) canoe- the hollowed trunk of coconut palm is used as small canoe by the Hawaiians; (15) soap- coconut oil is used as a basic ingredient in some of the cosmetic soap products; (16) toothpaste- coconut oil is also used as a basic ingredient to make toothpaste for sensitive teeth; (17) relieve minor skin irritations- coconut oil can also be applied to skin to treat minor irritations like insect bites and sunburn; (18) compost- the fiber of coconut husk is also used as compost in horticulture; (19) medical benefits of virgin coconut oil- virgin or pure coconut oil is believed to be

Plate 6. Date palm Tree in the field, NIFOR Sub-Station, Dutse**.**

Plate 7. Empty raphia palm fruit bunches.

Plate 8. Raphia roots.

beneficial to human. More and more research efforts are being put forward to prove that it has many medicinal values such as an important dietary supplement to boost up immune system, assists constipation or digestive problems, assists weight control, anti-cancer agents, anti- aging properties and many more; (20) dye- the roots of the coconut plant are used as a dye.

Date palm (*P. dactylifera*)

The date palm is a very important and popular tree crop found growing mostly in the arid regions of the world (Plate 6). It is useful because it produces fruits which are a source of high energy supplying food and raw materials for building and construction (Morton, 1987). The biomass produced by date palms includes the following: Leaves/fronds, fruit clusters (Plate 15), inflorescence (Plate 16) and tree trunk. With the exception of the trunk, the other biomass can be used as plant material in the production of organic fertilizer. These biomasses also have alternate uses. Young leaves are cooked and eaten among people of the near East and North Africa while mature leaves are used for religious purposes (Palm Sunday). Mature leaves are also woven into mats, screens, baskets, crates, fans, hats etc. The stripped fruit clusters are used for brooms while the wood from the trunk is used for construction and left over parts burned as fuel.

Date palm biomass can be composted with other nitrogenous sources such as poultry droppings and cow dung (Plate 17). Currently, the composting of date palm biomass (Table 3) is on-going at the Nigerian Institute for Oil palm Research (NIFOR) Sub- Station Dutse, Jigawa State (Plate 18).

Raphia palm (*R. hookeri*)

The origin of Raphia palm is traced to tropical West Africa based on the reports of several explorers, investigators and scientist (Daziel, 1937; Russel, 1965; Otedoh, 1974). Raphia palms are usually associated with swampy coastal areas of West Africa and tapped for wine. Over 28 species of Raphia palm has been identified and 8 of them found in Nigeria. *R. hookeri* is our primary focus here. The components of *R. hookeri* biomass include: The roots (Plate 8), the trunks, the leaves, the inflorescence and empty fruit bunch (Plate 7).

The roots can be used alternatively for medicinal purposes by the local farmers and traditional healers. The trunks are used for building materials, pulp for paper making, fire wood for cooking and warming of houses, breeding grounding useful larvae. The leaves are used as piassava, bamboo, raffia, brooms, roofing mats and black fiber while raphia inflorescence is tapped for palm wine, production of local gin and gaso oil. The fruits are used as growth regulators, fish poison (though no longer encouraged), human food, raphia oil and raphia seed.

Shea tree (*V. paradoxa*)

Available Shea tree (Plate 9) biomass includes the fruits, flowers, husks, foliage, roots and trunk. The husks make a good mulch and fertilizer (FAO, 1988a), and are also used as fuels on three stone fires (Plate 10). Shea tree

Plate 9. A typical Shea tree.

Plate 10. Shea fruits, seeds, nuts and leaves.

Plate 11. Shea fruits.

husks have a capacity to remove considerable amounts of heavy metal ions from aqueous solutions for example with waste water. These were found to be more effective than the melon seed husks for absorption of lead, Pb (11) ions (Eromosele and Otitolaye, 1994). There is need to conduct further research on the potentials of Shea husk.

Plate12. Shea nuts.

The following are some alternative uses of shea tree biomass: - The flowers are made into edible fritters. The fruit pulp, being a valuable food source, is also taken for its slightly laxative properties. Shea nut (Plate 12) cake is used for cattle feed (Salunkhe and Desai, 1986), and also eaten raw by children (Faegri, 1966) while the residual meal is used as a waterproof agent to repair and mend cracks in the exterior walls of mud huts, windows, doors and traditional beehives. The sticky black residue, which remains after the clarification of the butter, is used for filling cracks hut walls (Greenwood, 1929) and as a substitute for kerosene when lighting firewood (Wallace-Bruce, 1995).

The husks make a good mulch and fertilizer (FAO, 1988a), and are also used as fuels on three stone fires. Shea leaves (Plate 10) are used as medicine to treat stomach ache in children (Millee, 1984). A decoction of young leaves is used as a vapor bath for headaches. The leaves in water form a frothy opalescent liquid, with which the patients head is bathed. A leaf decoction is also used as an eye bath (Abbiw, 1990; Loupe, 1994). The leaves (Plate 11) are sources of saponin, which lathers in water and can be used for washing (Abbiw, 1990). Branches may be hung in the door way when woman goes into labour to protect the new born baby. Branches may also be used to cover the dead prior to their burial (Agbahungba and Depommier, 1989).The roots are used as chewing sticks in Nigeria, most commonly in savannah areas (Isawumi, 1978). Roots and bark are grounded to paste and taken orally to cure jaundice (Ampofo, 1983). These are used for the treatment of diarrhea and stomach ache (Millee, 1984). Mixed with tobacco the roots are used as poison by the Jukun of northern Nigeria. In horses, chronic sores are treated using boiled and pounded root bark of this plant (Dalziel, 1937). Infusions of the bark have shown to have selective anti-microbial properties, as being effective against *Sarcina lutha* and *Staphylococcus mureas* but not mycobacterium. Macerated with the bark of *Ceiba pentandra*, and salt, bark infusion have been used to treat cattle with worms in the tundra region of Senegal and Guinea (Ferry et al., 1974). The infusions have been used to treat leprosy in Guinea Bissau (Daziel, 1937) and for gastric problems (Booth and Wickens, 1988) as well for diarrhoea or dysentery. A bark decoction is used in Cote d'ivoire in baths and therapeutic sit-baths to facilitate delivery of women in labour, and is drunk to encourage lactation after delivery (Abbiw, 1990; Loupe, 1994). However, in northern Nigeria such a concoction is said to be lethal (Daziel, 1937). A bark infusion is used as an eye wash to neutralize the venom of spitting cobra and also, in Ghana, as a footbath to help extract jiggers. Greenwood (1929) noted that the stripping of the bark for medical purposes may have a severe impact on the health of Shea trees and may even be fatal. The wood is used only when the individual Shea tree is not valued for butter production.

This is because of the long gestation period of the tree crop as such farmers are reluctant to cut down any tree unless it is proven to be of inferior value for butter production. The latex is heated and mixed with the palm oil to make glue. It is chewed as a gum and made into balls for children to play with (Louppe, 1994). In Burkinafaso, musicians use it to repair cracked drums and punctured drumheads (Millee, 1984). It contains only 15 to 25% of carotene and, therefore, is not suitable for the manufacture of rubber.

COMPOSTING

Composting is the conversion of refuse into stable humus like substance under aerobic conditions. Composting offers an opportunity to recover and reuse a portion of the nutrients and organic fraction in agricultural wastes. Important factors in the process include intimate mixing of wastes, small particle size and oxygen for the microbial degradation of wastes, time to accomplish the composting and moisture. There are 2 main methods of composting organic materials. These include: - Pit method and windrow method. In the pit system, the sizes of the dug pit should be manageable in size (2×2×1) m^3 according to Gordon (1982). The wastes are piled up in layers inside the pit and in alternate manner. Nitrogenous source of fertilizer is placed between the pilled layers e.g. poultry droppings. The pit is left for 2 weeks after which it is transferred to another pit and then stirred. The windrow method is similar to the pit system except that composting is carried out on the floor surface rather than in a pit. Poles are inserted between the piles while preparing the compost to ensure better air circulation and then removed later (Chude et al., 2001).

Stages in compost preparation

There are 3 stages in compost preparation and each stage is associated with peculiar groups of microorganisms. The 3 stages include: The initial, active and curing stage. Maturity of compost is determined when pH reading ranges from 4.5 to 6.0 and temperature is stabilized at 30°C. Compost Preparation follows the concept of:

Mesophilic ⟶ Thermophilic ⟶ Mesophilic ⟶ Curing

In the initial stage, Mesophiles (fungi) predominate. Other organisms are exposed to the compost before the composting process starts. Mesophiles release heat. The active stage is the second phase. Here, most organic matter is converted to CO_2 and humus. Many microbes remain to be discovered and described due to limitations with isolation techniques. Few genera of bacteria isolated from thermophilic stage include *Bacillus*, *Clostridium* and *Thermus*. Properly ventilated composting pile maintains an appropriate temperature of 131 to 155°F. High temperatures ensure rapid organic matter processing while simultaneously providing optimal conditions for the destruction of human and plant pathogens as well as weed seeds. Mixing prevents temperatures from exceeding 160°F which effectively stops all microbial activity. Air pores created also serves as a passage for oxygen required by microbes to efficiently breakdown organic matter. Overheating occurs at 170°F upwards. Most microbes die and microbial activity ceases. Surviving microbes are usually in spores and return/germinate when the temperature becomes favourable. If the compost pile is too low in readily utilizable organic substrates, pile may not be able to support the microbial activity needed to return to thermophilic conditions. It may then be necessary to supplement the composting pile with additional feedstock to ensure maximum degradation and pathogen removal. At the curing stage, a properly functioning pile will deplete itself of a majority of easily degradable substrates leaving behind some cellulose, mostly lignin and humic materials for mesophiles that is, fungi and actinimycetes to act upon. This is the final stage of compost curing and is characterized by inability to identify the plant or other organic parts. Humification is characterized by increase in concentration of humic acids from approximately 4 to 12% and a decrease in C/N ratio from 30 in original material to 10 in the final product.

Fungi and actinomycetes use extracellular enzymes to degrade chitin, cellulose and lignin which are insoluble in water. Fungi, though they grow and respond more slowly than bacteria are well suited for exploiting an environment rich in complex recalcitrant organic compounds like those found in compost at curing stages.

Quality of raw materials for organic fertilizer production

Studies on the utilization of oil palm by-products such as mulching with pruned fronds, empty fruit bunches (EFB) and palm oil mill effluent (POME) as replacement for

Table 1. Nutrient contents in by-products obtained from a hectare of oil palm (kg/ha/year).

Part of palm	N	P	K	Mg	Ca
Annual pruning	107.9	10.0	139.4	17.2	25.6
Empty bunches	5.4	0.4	35.3	2.7	2.3
Fibre	5.2	1.3	7.6	2.0	1.8
Shell	3.0	0.1	0.8	0.2	0.2
Effluent (raw)	12.9	2.1	26.6	4.7	5.4

Source: Tarmizi (2000).

Table 2. Nutritive value of raw and composted coir pith compost.

S/N	Parameter	Raw coir pith (%)	Composted coir pith (%)
1	Lignin	30.00	4.80
2	Cellulose	26.52	10.10
3	Carbon	26.00	24.00
4	Nitrogen	0.26	1.24
5	Phosphorous	0.01	0.06
6	Potassium	0.78	1.20
7	Calcium	0.40	0.50
8	Magnesium	0.36	0.48
9	Iron(ppm)	0.07	0.09
10	Manganese(ppm)	12.50	25.00
11	Zinc(ppm)	7.50	15.80
12	Copper(ppm)	3.10	6.20
13	C:N ratio	112.1	24:1

Source: Department of Environmental science; Centre for Soil and Crop Management Studies (2008) Tamil Nadu Agricultural University.

Table 3. Nutritive value of different parts of the date palm biomass.

S/N	Sample description	P (%)	Ca (%)	Mg (%)	K (%)	Na (%)	N (%)
A	DTPBHS	0.058	0.275	0.160	0.969	0.047	0.228
B	DTPB	0.032	0.281	0.190	0.958	0.043	0.082
C1	DTPB	0.043	0.257	0.112	0.922	0.045	0.179
C2	DTPB	0.088	0.160	0.065	0.935	0.030	0.077

A = DTPBHS = Date palm bunch stem; B = DTPB = Sticks of bunches; C = DTPB = Flowers. Source: Aisueni et al., Date palm task execution report, NIFOR (2009).

chemical fertilizers have been done extensively with encouraging outcomes. Table 1 shows the various nutrient contents that can be obtained from a hectare of oil palm. Composition analysis of EFB reveals that 1 tonne of EFB (fresh weight) has the fertilizer equivalent of 7 kg urea, 2.8 kg rock phosphate, 19.3 kg muriate of potash and 4.4 kg kieserite (Singh et al., 1999).

The interaction between EFB application and chemical fertilizer on inland soil improves oil palm growth and increases yield by up to 75% (Singh et al., 1999), while on coastal soil, the response depends on the type of alluvium. After taking into account the transport costs for the EFB, the savings in fertilizer can reach 28% less than the prior cost (Nasir, 2001).

In the coir pith composting technology, coir pith (pulverized and sieved coconut husk) is collected from the coir industry without any fiber. If fibrous materials are present, it is removed by sieving at the source itself. Otherwise, it has to be removed at the end of composting at the compost yard. These fibrous materials will not get composted and it will hinder with composting process. It is advisable to bring fiber free coir pith for composting. In choosing a site for composting, a separate area should be earmarked. It is better to have

Plate 13. Typical cells used in composting, NIFOR main station, Benin City, Edo State.

Plate 14. Coir pith heap.

Plate 15. Sticks of bunches.

Plate 16. Flowers.

Plate 17. Cow dung.

Plate 18. Compost cells under construction.

an elevated place for composting. In between coconut trees, shade under any tree is good for composting. The shady area conserves the moisture in the composting material. The floor of the compost making area should be leveled. If earthen floor is available the floor can be made hard by hard pressing and also by applying cow dung slurry. Presence of roof over the composting material is advantageous, since it protects the material from rain and severe sunshine (Plate 13).

Initially coir pith should be put up for 3 inch height and thoroughly moistened. After moistening, nitrogenous

Table 4. Tolerable contents of some micronutrients and heavy metals in soils with regard to their plant compatibility.

Nutrients	Tolerable limits (proposal) (Mg kg)	Percentage
Zn	300	0.03
Cu	100	0.01
Be	100	0.01
F	500	0.05
Cr	100	0.01
Ni	100	0.01
Co	50	0.005
As	50	0.005
Se	10	0.001
Mo	10	0.001
Cd	5	0.0005
Hg	5	0.0005
Pb	100	0.1

source material should be added. The nitrogenous source may be in the form of urea or fresh poultry litter. If urea is applied, it is recommended that 5 kg urea is required for one ton of coir pith. This 5 kg equally divided into five portions and in alternative layer of coir pith one kg of urea should be applied. If fresh poultry litter is applied, it is recommended at 200 kg for one ton of coir pith (1:5, poultry droppings to coir pith). The compost heap should be turned once in 10 days to allow the stale air trapped inside the compost material to go out and fresh air will get in. The composting process is an aerobic one; the organisms decomposing the materials require oxygen for their metabolic activity.

Composting of date palm biomass can be done using pits or cells/ compost compartments. The material being composted (empty date palm bunches) are cut to smaller sizes following the addition of cow dung sub-samples to the various parts of the date palm biomass pieces. The cow dung and date palm biomass are mixed together and turned from one cell to another to allow even distribution and decomposition of the organic materials. For Raphia palm and Shea tree, research needs to be carried out to explore the possibilities and determine the most suitable parts of the trees for compost making.

Compost as a soil conditioner impacts the following properties when applied to soils: Lightens heavy soil, improves the texture of light sandy soil, increases water holding capacity, base saturation, cation exchange capacity and buffering capacity of soil, contributes to the enlargement of the root systems of plants and bioremediation of oil spills or derelict lands. Characterization of various sources of nutrient from organic sources reveal the following limitations: Low levels of plant nutrients, non-available forms of plant nutrients, sub-optimal contents of trace elements, excessively high content of obnoxious and toxic metals, high C:N ratio and objectionable odour (Table 4).

Specification/standards for organic fertilizer

The under listed criteria must be satisfied before any material of organic origin is accepted as organic fertilizer (FAO, 1994):

1. The minimum content of N: 1 to 4%
2. The minimum content of P: 1.50 to 3%
3. The minimum content of K: 1 to 1.5%
4. Moisture content should not exceed: 15 to 25%
5. Total organic matter content should at least: 20% or more
6. Carbon: Nitrogen (C/N Ratio)10: 1 to 15: 1
7. pH: 6.5 to 7.5
8. Odour: Free
9. Non –biodegradable materials such as glass, metal
10. Splinters: Free
11. Colour: Variable
12. Texture: Variable
13. Pathogens: Free

Acceptability, standardization and certification of organic fertilizer

Acceptability of the fertilizer depends on its availability. These fertilizers are not as readily available as inorganic fertilizers. This tends to increase the cost of the product. The cost of these organic fertilizers is more expensive than the conventional inorganic but with the transfer of the knowledge of composting to farmers, organic fertilizers can be produced at little or no extra cost. Handling- The locally produced composted organic fertilizers are bulky as a result farmers may prefer to go for the inorganic fertilizers still. It is however established that for mature palms, EFB 37 tonnes/ha/year or 258.7 kg/palm/year (Loong et al., 1987). For nursery seedlings, 150 g compost / nursery bag is sufficient (Aisueni et al., 2000). The standardization of any organic fertilizer follows or should conform with the rules and standards specific to that country. In the case of acceptability, the exportation of such a product will have to conform to the standard of the importing country. The International Federation of Organic Movement (IFOAM) is a body responsible for the standardization of production and processing of organic products. The IFOAM accreditation criteria for bodies certifying organic production and processing are called IFOM Norms. In Nigeria the Nigerian Organic Agriculture Network (NOAN) with its head quarters in the Faculty of Agriculture, University of Ibadan Oyo State is a non-governmental organization created to coordinate the activities of all stakeholders in organization production. More information on the criteria, acceptability levels and conditions required for the preparation and utilization of organic fertilizers from composted materials can be found in the IFOAM Norms (www.ifoam.org).

BENEFITS OF ORGANIC FERTILIZERS TO THE NATIONAL ECONOMY

The use of organic fertilizers will provide an environmentally friendly, naturally sustainable, safe and affordable means for maintaining soil fertility and increasing crop production. It will also lower the cost on the importation of inorganic fertilizers. This will ensure food security and improve the standard of living of Nigerians.

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REFERENCES

Abbiw D (1990). The useful plants of Ghana. Intermediate Technology publications/Royal Botanic Gardens, London/kew. P. 337.
Agbahungba G, Depommier D (1989). Aspects du parc a karites-neres (vitellaria paradoxa Gaertn F. parkia biglosa jacq. Benth.) dans le sud du Borgou (Benin). Bois et forets des Triopiques. 222:41-54.
Aisueni NO, Oviasogie PO, Brown G, Eguagie EI (2009). Evaluation of Cow dung based compost for commercial production of Bio-fertilizer. Date palm task execution report, NIFOR sub –station Dutse, Jigawa State.
Aisueni NO, Omoti U, Ekhator F, Oviasogie P (2000). Effects of compost on soils supporting Nursery seedling Production of oil palms. Nigerian J. tree crops Res. 4(2):43-51.
Ampofo O (1983). First aid plant medicine. Ghana rural reconstruction movement, Yentsi Centre, Mampong.
Asian Development Bank, ADB (2006). Technology overview–palm oil waste management- Appendix VII.
Basri MW, Maizura I, Siti Nor Akmar A, Norman K (2003). Oil Handbook of Industrial Crops". (Eds. V Haworth Press, New York. (In press).
Booth FE, Wickens GE (1988). Non-timber uses of selected arid zone trees and shrubs in Africa. FAO conservation guide, 19:1-176.
Chude VO, Osno AO, Uzoigwe GA (2001). Proceedings of an In – House Workshop On organic fertilizer development.
Daziel JM (1937). Useful plant of West Africa. Crown Agents, London. P. 612.
Department of Environmental science Centre for Soil and Crop Management Studies (2008). Composting technology and organic waste utilization in Agriculture. Tamil Nadu Agricultural University, Coimbatore-641 003, 2008.
Eromosele IC, Otitolaye OO (1994). Binding of iron, zinc and lead ions from aqeous solution by shea butter (Butyrospermum pakii) seed husks.bulletin of Environ. Contaminat. Toxicol. 52 530-537.
Faegri k (1966). Some problems representativity in pollen analysis. Palaeobotanist,15:135-140.
FAO (1988a). Appendix 5, forest generic resource priorities. 10. Africa. Report of sixth session of the FAO panel of experts on Forests Gene Resources, held in Rome, Italy, December 8-11, 1985, pp 86-89. FAO, Rome. p.79.
FAO (1994). Standards for organic fertilizers. In: organic recycling in Asia and the pacific. RAPA Bulletin 10:86.
Ferry MP, Gessain M, Geeain R (1974). Ethnobotanique tenda. Documents du centre de researches Anthropologiques du muse de l"Homme, paris.
Greenwood M (1929). Shea nuts and shea butter. Bulletin of the Agricultural Department, Nigeria. pp.59-100.
Hartley KT, Greenwood M (1933). The effect of small applications of farmyard manure on the yield of cereals in Nigeria. Emp. J. Exp. Agric.1:119-121.
Isawumi MA (1978). Nigerian chewing sticks. Nigerian field. 43:50-58.
Karen C (2008). Palm oil In: Environmental Management for Palm Oil Mill by Kittikun, A.H. et al., http://www.hi.sierraclub.org/maui/palmoil.html.
Loong SG, Nazeeb M, Letchumanan A (1987). Optimising the use of EFB mulch on oil palms on two different soils.1987 Kuala Lumpur, Malaysia.
Loupe D (1994). Le karate en cote d"i international en Researche Agronomique pour le Development, Montpellier. P. 28.
Mille JK (1984). Secondary products of species native to the Dinderesso Forest Reserve, Forest Educational and Development project USAID, Ouagadougou.
Morton J (1987). Date: In Fruits of Warm Climates. F. J. Morton. P 5-11.
Miami FI, Odeyemi O (1991). Development of Brady rhizobium inoculant (Bio fertilizer) for legume Inoculant. In proceedings of the first National seminar on organic fertilizer in Nigerian Agriculture; Present and Future, kaduna, 5-8 March, pp. 86-98.
Otedoh MO (1974). Raphia oil, its extraction,proparties and utilization. J.Nig.Institut. Oil palm Res. 5(19):45-49.
Rafiu-Adio OT, Fadare TA, Osonubi O, Idowu EO, Amure A, Awoyemi AO, Olaniyan A (2000). Evaluationof the effects of micorrhiza on crop yield. A paper Pesented at the 13th South West Zonal Refils Workshop, I.A.R. & T., Moor Plantation Ibadan., Feb. 14-18th.
Rahman SHA, Choudhury JP, Ahmad AL (2006). Production of xylose from oil palm empty fruit bunch fiber using sulfuric. Biochem. Eng. J. 30:97-103.
Russel TA (1965). The Raphia palms of West Africa. Kew Bull. 19(2):173-196.
Salunkhe DK, Dessai BB (1986). Postharvest biotechnology of oilseeds. CRC, Boca Raton. P. 264.
Singh CP, Amberger AA (1991). Solubilization and availability of palm. „In L Chopra and K V Peter) The and urine. Biol. Agric. Hort. 7:261-269.
Toyota K, Kuninaga S, (2006). Comparison of soil microbial community between soils amended with or without farmyard manure. Appl. Soil Ecol. 33:39–48.
Yusoff S (2006). Renewable energy from palm oil-innovation effective utilization waste. J. Cleaner Prod. 14:87-93.
Wallace-bruce Y (1995). Shea butter extraction in ghana, In: Do it Herself. Women and technical innovation. (Ed. By H. Appleton), pp.157-161.