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THE OIL PALM (*Elaeis guineensis* Jacq): NATURE'S ECOLOGICAL ENDOWMENT TO EASTERN NIGERIA

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ABSTRACT

The paper highlights oil palm as a multipurpose tree crop symbolizing nature's endowment to the people of South East, Nigeria, and presents available evidence that the center of origin for the palm is within the area. The structure of the natural habitat of the oil palm – the groves, from where several genetic collections have been made for the improvement of the crop worldwide – is described. The oil palm is viewed as closely interwoven with the people providing their requirements in terms of food, medicine and materials for infrastructural development. In a wider context, the ecological, socio-economic, and socio-cultural and traditional values of the palm are discussed. The history of efforts to exploit the potentials of the crop through domestication and genetic improvement is given. Because the potential of oil palm is yet exhausted, the action plan for further development in the natural habitat and plantations is also given, highlighting the prospects of increased oil palm production as well as some of the constraints on the way to realising this all-important project. The paper identifies areas needing action research towards the sustainable development of oil palm. Among other suggestions in this direction, the paper recommends the creation of a center of excellence in oil palm studies within the South East, Nigeria to expand the scientific exploitation of the natural groves and encourage plantation establishment for the benefit of not only the people whose God-given gift is now a highly valuable crop in the world, but the entire country and even beyond.

Key words: multipurpose tree, natural groves, oil palm plantations, agricultural growth, South East Nigeria

INTRODUCTION

Oil palm (*Elaeis guineensis* Jacq) is a monocotyledonous plant belonging to the palm family *Arecaceae*. It is a monoecious species known to produce unisexual male and female inflorescences in an alternating cycle (Barcelos *et al*., 2015). Oil palm is, no doubt, the richest tree on earth in terms of natural endowments. It is one of the best trees given by God to man in the tropics for his survival and for all his vegetable oil and related needs. It has been described as the 'tree of life' not only because every part of the tree is useful to man but also because it lives and flourishes for many years. At present, oil palm produces the highest yield (output per land area) of vegetable oil of all known oil crops (Corley and Tinker, 2007).

The oil palm is widely believed to have originated in Africa, specifically in the tropical rainforest region of West Africa known to have wild and semi-wild palm groves along the coastal belt (Poku, 2002), and there is abundant evidence to support this notion. The pieces of evidence supporting the West African origin of oil palm can be placed under three categories namely fossil, historical and linguistic evidence. For the fossil evidence, the use of oil from the palm by man in Africa dated as far back as 5000 BC as evidenced by the discovery of oil in the tomb at Abydos in Egypt (Raymond, 1961). Pollen similar to that of the palm has been extracted by Zeven (1964) from Miocene sediment in Eastern Nigeria.

Historical evidence of the West African origin of palm comes from the writings of early European explorers who reported in 1424 about the existence of oil palm in West Africa. Also, the botanical name *Elaeis guineensis* given to it by Jacquin in 1763 was from plant specimen collected from the region. For the linguistic evidence, the Brazilian terms for the palm are of African origin, just as most West African tribes have not only vernacular names for oil palm, but also traditional methods of planting, harvesting and palm fruits processing (Hartley, 1988). Processing of the fruits of oil palm, for instance, is an indigenous technology in Nsukka area in present day Enugu State in southeastern Nigeria (Agu and Okagu, 2013).

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Among palm populations collected from some African countries, the highest allelic diversity was found in Nigerian populations which also were genetically very similar to semi-wild populations of African oil palm found in Bahia Brazil, pointing to Nigeria as the possible center of origin of oil palm (Bakoumé *et al*., 2015). Besides the fossil evidence provided by Zeven (1964), there is ample evidence to believe that the oil palm was initially endemic in Eastern Nigeria. The Brazilian groves were very similar in composition and fruits yields with those from southeastern Nigeria (Hartley, 1988). In terms of morphological and other characters, the highest diversity of oil palm occurs in the region, precisely the Orlu/Mbaise axis. Plants generally exhibit highest diversity in their centers of origin; therefore, it is widely believed that the centre of origin of oil palm is South East, Nigeria (Omoti, 2003). Furthermore, Agu and Okagu (2013), who view oil palm tree as a blessing of inestimable value to the people of Nsukka area in the zone, infer that the tree is as old as settlement by humans in the area, based on archaeological evidence of palm fruits processing during the late Stone Age, dating to 2555±130 BC.

NATURAL HABITAT OF THE OIL PALM

Because oil palm flourishes at the instance of man's activities when he fells forest trees for settlement or farming, its original habitat is difficult to determine; however, Chevalier (1934) suggested that the original habitat was in forest outliers close to rivers probably in association with the raffia palm (*Raphia farinifera*). In such places the forest may not be as densely vegetated as to shade palms out and water supply will normally be excellent. Such forest fruits along rivers are abundant in tropical Africa and especially Eastern Nigeria. Oil palm naturally does not grow in forest but will become the pioneer species as soon as felling occurs.

Apart from the southern Nigeria where oil palm is predominantly found, wet parts of North Central Nigeria as well as the Federal Capital Territory support oil palm growth (Ekenta *et al.*, 2017). Oil palm does well in other tropical locations and could be said to be generally associated with climate and vegetation as well as with man and his activities. For instance, Malaysia which too represents a tropical climate is among the leading producers of oil palm in the world (The Nation, 2015a).

The Oil Palm Groves

In Eastern Nigeria, shifting cultivation was widely practiced and the forest fallow period was usually short, such that few trees of considerable height were maintained. This rather outdated farming practice accorded the palms some kind of privilege in that they were always protected and unshaded, so they usually yielded relatively well and formed productive groves. Contemporary crop production systems in the region still accords oil palm trees similar privilege of not being felled indiscriminately; instead they are often allowed as a 'harmless' component of the cropping systems. This practice prevails not only in Eastern Nigeria but in the entire West Africa. Therefore, the oil palm grove in West Africa consists of a collection of palm trees of varying ages randomly scattered over an area where shifting cultivation was the dominant agricultural system. Zeven (1965) classified groves based on palm and tree diversity (Table 1).

However, the interaction between man and his oil palm, represented by the proximity of the palms to human settlement and by farming activities around the palms, could also be used to classify groves. The existence of certain scenarios of man-palm ecological interactions in Eastern Nigeria is recently being viewed as throwing up three major types of groves in the region, as shown in Table 2 (Okolo *et al*., 2012).

Table 1: Classification of oil palm groves based on diversity of oil palm and other trees, after Zeven (1965)

Type	Characteristics
Secondary forest	Low yield (1.50 of fresh fruit bunch (FFB) tonnes/ha/year); low palm density; slow palm growth
Palm bush	75-150 palms/ha; yields over 2.0 tonnes FFB/ha/year; farming relatively frequent
Dense grove	Almost pure stand of plants; high density with arable land
Thinned grove	Palms deliberately thinned to allow in more light to achieve higher yields of food crops
Sparse grove	40 palms/ha; frequent arable land cropping with attendant soil degradation, leading to derived Savanna with few isolated palms

Table 2: Classification of oil palm groves based on the proximity of palms to human settlement and farming activities around the palms (Okolo *et al*., 2012)

Type	Occurrence	Characteristics
Homestead groves	Within the confines of compounds and their immediate surroundings, common in Anambra, Imo, Abia, Rivers, Cross River and Akwa Ibom States	Usually robust and high-yielding oil palm trees, with characteristically heavy bunches
Farm groves	Arable crop farms	Usually heavily pruned annually to allow sunlight for the crops growing below; palm density usually lower than that found in the homestead groves
Wild groves	Secondary forests	Community owned; typically tall old palms that are untended and rarely harvested; low palm regeneration because of the presence of dense shrubs and trees

Notably, the oil palm groves are densest where the human population is largest as in Eastern Nigeria. Because of this interaction between man and the oil palm, the wild grove will ever play a crucial role in the oil palm industry. It is argued that once oil palm becomes fully domesticated and cultivated, the wild and semi-wild palms would lose their economic place which implies no room for exploitation of these natural groves. In support of this view, the wild oil palm groves of Central and West Africa consist mainly of a variety that is thick-shelled but with a thin mesocarp, called *Dura* (Poku, 2002), which differs from a shell-less variety called *Pisifera*. It was through breeding work involving crosses between these two varieties that a hybrid, *Tenera*, with a thinner shell and a much thicker mesocarp was developed.

MULTIPUROSE ROLES OF OIL PALM

Ecological Benefits of the Oil Palm

Oil palm trees are a part of the natural ecosystem in especially Eastern Nigeria. In this region, most residential premises in the rural areas have pockets of palm trees as dominant economic trees in and around the home farmsteads. Both the palm trees in this category and those in plantations provide an array of ecosystem services. First, they often serve as windbreaks, while moderating the microclimate via the shade they provide to the prevailing under-storey atmosphere and soil surface. Because of this foliar shading, oil palm trees support the growth of such shade-loving, lower-storey compatible intercrops as cocoyam (*Xanthosoma sagittifolium*) (Salako *et al.*, 1995; Igwe, 2001). Otherwise, undergrowths are a part of oil palm plantations, and they have been reported to enhance soil biodiversity (Ashton-Butt *et al*., 2018). Again, certain epiphytes and insects are known to be associated with oil palm (Adeleye *et al*., 2016; Suzanti *et al*., 2017), as with most forest trees (Adubasim *et al.*, 2018). The association can be evident for the tall oil palm trees in natural and semi-wild groves. As a fruit-bearing tree, oil palm also attracts such arboreal rodents as squirrel. In all, oil palm trees in the long term support the growth of various plant species as well as attract a variety of animals; therefore, the trees could be said to play crucial roles in promoting ecological balance.

Furthermore, the establishment of oil palm groves or plantations can minimize environmental degradation through reduced loss of plant nutrients to leaching in the soil (Omoti *et al*., 1983). A related major ecological benefit of palm groves/plantations is that they help to minimize soil erosion by water, a popular environmental problem in particularly the southeastern region of Nigeria. Palm trees offer the much-needed protection to the soil and the entire environment by at least two mechanisms; (i) ability of the closed tree canopy to intercept the usually high-intensity rainfall, thereby reducing its erosive power upon reaching the ground, and (ii) enhanced structural-hydraulic properties of soils. This implies increased rainwater infiltration/retention in the soil, such that palm trees serve as a biological measure of agricultural water conservation (Obalum *et al*., 2011). Regarding the required improvements in soil structural-hydraulic properties, oil palm plantation has severally been reported to be superior to arable cropping in southeastern Nigeria (Igwe, 2001; Ogban, 2017; Uzoma and Onwuka, 2018).

Socio-Economic Attributes of the Oil Palm

As a multipurpose tree, oil palm has a high socio-economic value as virtually every part of the tree can be put into a gainful use. In view of the different uses of the parts of the tree, the oil palm industry offers employment to many citizens and foreigners thus helping to reduce unemployment. By serving as a source of revenue for many families in rural areas of Nigeria, oil palm improves the economy of the country (Onoh and Peter-Onoh, 2012). Oil palm does not only create employment and revenues for many rural families in Nigeria, but also improves the general livelihood of the people. For instance, the trunk is useful for building traditional houses and farm settlements. Palm trunk is also used as local culverts and as wedge against soil erosion. Palm fronds are used in yam staking and as a cheap material to construct well-aerated yam barns, erect make-shift canopies during ceremonies, and make thatched fences round residential premises. Also, palm fronds are fed as fodder to sheep and goats. The veins of the tree are used in making brooms and its fibre is woven into baskets, fish traps and climbing ropes. Notably, oil palms are tapped to get palm wine, a highly-valued natural beverage. Palm wine has economic value as its tapping and marketing is a source of income to many rural households (Okereke, 1982; Onuegbu *et al*., 2015).

The massive employment created by the oil palm is due to the fact that a lot of economic activities go into in its agronomic production and processing. For instance, many labourers are needed in establishment and maintenance of the plantation, harvesting, threshing of bunches and picking of the palm fruits, and many more are needed in the processing of the fruits into some of its core products, among which are palm oil and palm kernel. Although the palm kernel often serves as sole or complementary snacks (Aghalino, 2016), it can be processed further into palm kernel oil and palm kernel cake. The oil palm is thus considered a prime plant for the production of vegetable oil, producing two types of oil viz palm oil from the mesocarp and palm kernel oil from the kernel, unlike most other oil-producing plants. These two types of oil are in high demand all over the world, with palm oil being the major product. The palm oil goes with many socio-economic attributes, serving both food and industrial purposes.

Interestingly, virtually none of the materials released during the processing of palm fruits and which are perceived not to have any immediate socio-economic value at the time of picking the desired goods could be considered 'wastes'. These supposedly waste materials can be put to beneficial uses. The leftover after detaching the fruits from the bunch, popularly referred to as empty fruit bunch, has traditionally been used in soil and water management for especially the purpose of arable crop production. The empty fruit bunch serves as mulch material and too can be composted and used as organic fertilizer. It has also found use as a feedstock for high-quality biochar (Idris *et al*., 2014; Bakar *et al*., 2015; Rozhan *et al*., 2015). The empty bunch, when burnt, can be used to make local soap. Also, palm oil-mill effluents or wastewaters released during palm fruit processing are potential rich organic fertilizers for enhancing crop production in low-fertility tropical soils (Nwoko and Ogunyemi, 2010; Eze *et al*., 2013; Mohd Nizar *et al*., 2018); however, such vegetable oil-mill effluents must be treated or fermented properly before use to avoid inhibiting crop growth (Okorie *et al*., 2017; Ubani *et al*., 2017).

Furthermore, the mesocarp fibre which is what is left of the mesocarp of the fruit after extracting palm oil, being a fibrous material, contains palpable levels of residual oil, making it to be flammable. This attribute of the mesocarp fibre makes it a good candidate for use as cooking fuel in rural areas, sparing firewood whose increased use negatively impacts on the preservation of forest tree resources. In some places, collections of palm kernel shell are not discarded but serve as local beddings/slabs in marshy portions of residential areas (Aghalino, 2016). What is more, depending on level of technological development and relative needs of the people, the bulk of the total dry matter of the tree offers opportunity for assuaging the increasing world demand for energy. This is because, once palm oil – the most important economic yield from the oil palm – is secured, the remaining cellulose-rich dry matter can be used in bio-fuel production (Ekenta *et al*., 2017). Some of the several parts of the oil palm and their utilities and values to man are summarized (Table 3).

Table 3: Some parts of the oil palm and their uses

Oil palm part	Uses or values to man
Roots	Medicine
Trunk	Timber in local housing, culverts and erosion control; firewood; breeding ground for edible Rhinoceros beetle
Fronds/leaves	Thatching; fencing; yam staking; fodder; making of brooms, baskets, fish traps, etc.
Young male inflorescences	Tapped for wine known as palm wine
Empty fruit bunch	Mulching, local fertilizer, substrate for biochar, manufacturing of black soap
Fruits	Palm oil, palm kernel, palm kernel oil, palm kernel cake, palm kernel shell, mesocarp fibre, palm oil-mill effluents

The Place of Oil Palm in Economy of Nigeria - Focus on Palm Oil

In Eastern Nigeria, oil palm contributes so much to the rural economy in that proceeds from the rural oil palm industry largely sustain the rural population. Most prominent persons in the region today were trained using proceeds from palm trees. In some areas many community developmental projects are financed with proceeds from sale of oil palm fruits.

The development of palm oil market all over the world was based on raw materials obtained from palm groves of West and Central Africa and on the various uses of palm oil. As soon as these uses became established, the demand for palm oil grew automatically with the wealth of the developed countries, putting an end to the slave trade. Henderson and Osborn (2000) support the case that it was the explosion of demand for palm oil that really ended the slave trade in West Africa, as local chiefs found it more profitable to export the oil.

In the 1950s till mid 1960s, Nigeria was said to have remained the largest producer of crude palm oil in the world with a market share of 43%, supplying 645,000 MT of palm oil, on annual basis, across the globe (Daily Independent, 2014). Today, Nigeria has conceded this feat to Malaysia and Indonesia which together can boast of 83% the world's total production of palm oil, while Nigeria can boast of only 1.7% of which is insufficient to meet its domestic consumption which stands at 2.7% (The Nation, 2015a). Therefore, Nigeria, from being the largest producer, is today a net importer of palm oil. In 2014, for instance, the domestic production totalled 930,000 MT (The Nation, 2015a). This value, when compared with the domestic consumption which fluctuates between 1 and 2 million MT per annum (The Nation, 2015a,b), shows that the annual shortfall could be as high as 1,070,000 MT. This wide gap between demand and supply of palm oil in Nigeria offers huge investment opportunity for investors in the agricultural sector and employment opportunity for especially fresh graduates of agriculture and allied disciplines.

It should be noted, however, that about 20.0% of the palm oil produced in Nigeria is certified to be of high quality and clears all the 17 tests for being an exportable commodity (The Nation, 2015a). This category of palm oil which currently stands little or no chance of being exported because of the aforementioned shortfall goes with some premium in terms of food and nutrition security. Some are utilised by down-stream industries. In Nigeria, 90.0% of palm oil is consumed by the food industry, with products like noodles, vegetable oil, biscuits, margarines, shortenings, cereals, baked stuff; the remaining 10.0% is used by the non-food industry including those from even the detergent and cosmetic industries that make use of palm oil (The Nation, 2015b). Some of the products obtained from palm oil are listed in Table 4.

Table 4: Some examples of the several food and non-food industrial products from palm oil

Food products	Non-food usage
Cooking oil	Cosmetic
Deep frying oils	Detergents and Soaps
Margarines	Drugs
Shortenings	Candles
Spreads	Lubricating oils and Biodiesel
Alternative fats	Leather
Confectionary fats	Paints
Ice creams	Chemicals and Surfactants
Others	Electronics

Socio-Cultural and Traditional Values of the Oil Palm in Southeastern Nigeria

The core centers for oil palm production in Nigeria is the southeastern region which, consequently, has enjoyed the many benefits of oil palm for sustainable livelihood. Beyond this economic consideration, oil palm is in deep connection with diverse social, cultural and traditional practices of the Igbo people of this region. Therefore, the discourse on the numerous values of oil palm to man cannot be complete without mentioning its roles in terms of food and nutritional values, trado-medicare and human health, and tradition of the people.

Palm oil tops the list of oil palm products for such additional values. It is almost an indispensable ingredient for cooking local dishes. Palm oil makes the menu appealing to the eyes and so enhances its acceptability. A popular local rice stew of the Igbos, known as *ofe akwu* (palm fruit stew), is even palm fruit-based, as suggested by the name of this native delicacy. In nutrition terms, palm oil is known to have high contents of α- and β-carotene and Vitamins A and E with numerous health benefits (Nagendran *et al*., 2000; Sommerburg *et al*., 2015). Palm kernel oil, which too contains Vitamin E and is known be rather free of cholesterol, also offers numerous health benefits. It often serves as local pomade or pain-relieving liniment with impressive therapeutic effects (Aghalino, 2016). In Africa, the trado-medical practice of rubbing, inhaling and ingesting of the palm kernel oil has been used to effectively manage convulsion in children.

The list of products from oil palm also includes palm wine which is widely viewed not just as natural alcoholic beverage, but also as a delicacy by alcohol consumers. In this era of premium on natural organic foods, consumer preferences are increasingly tilting toward palm wine. It is a beverage for good eyesight due to its high content of yeast, just as it is believed to enhance the efficacy of malarial herbs when used as a medium to soak and administer such herbs (Chandrasekhar *et al*., 2012; Onuegbu *et al*., 2015). Besides, palm wine has strong socio-cultural and traditional importance among the Igbos of Eastern Nigeria, where it not only represents conviviality, but also occupies an unrivaled position in major traditional – including marriage – ceremonies when it plays indispensable roles (Onuegbu *et al*., 2015).

Sometimes, land boundary disputes are resolved in local communities using oil palm trees serving as landmark features in residential and farmed areas. Leaflets of the spear leaf (frond) of the tree, called *omu nkwu* by the Igbos of southeastern Nigeria, are used as sacramentals in the tradition of the people (Chuku, 2004; Agu and Okagu, 2013). Similar to this role, palm fronds have religious significance as they are used on Palm Sundays in the Christendom. The roots of the tree either alone or combined with other herbs can be used to treat certain aliments in trado-medicine. The nexus between especially the *virescens* fruit type of oil palm called *Akwu Ojukwu* and the potency or otherwise of charms is well known to traditional doctors in Igboland.

OIL PALM IMPROVEMENT

With the numerous beneficial attributes of oil palm, it became logical to not only cultivate the oil palm (Corley and Tinker, 2007), but also to tap into the enormous genetic resources of the plant. Oil palm breeding work in Nigeria started in 1922 because of the considerable awareness of the value of oil palm genetic resources. Much has been achieved in this regard through concerted research efforts at the Nigerian Institute for Oil Palm Research, NIFOR (Ujadughele and Osagie, 2016). At the onset, genetic blocks were established with materials selected entirely from botanical gardens in Calabar, Aba and Nkwele groves in Eastern Nigeria. During 1939-1941, the F_1s and selfings of these early selections were planted at the Oil Palm Research Station (OPRS), now NIFOR Main Station in Benin City, Nigeria. In the subsequent years (as from 1950s) selections were also carried out in well-defined grove areas at Ufuma and Aba, both again in southeastern Nigeria. This exercise involved the selective conservation followed by exploitation of 48- and 8.8-ha groves situated at Ufuma and Aba, respectively. At Ufuma, 2% (19 *Dura* and 25 *Tenera*) of the oil palms were selected, while at Aba, 3% (42 *Dura* and 3 *Tenera*) of the oil palms were selected. Bulk pollen from the selected palms was used at the respective locations in controlled pollination of each selected oil palm in D-×-D and T-×-T crosses.

In the late 50s and early 1960s seeds produced from these early selections were used to establish nurseries in various parts of Eastern Nigeria. Seedlings from these nurseries were distributed to farmers free in an effort by the then Eastern Nigerian administration to encourage organised planting of the oil palm. The Government established large oil palm plantations in some locations – Erei, Obotme, Ihechiowa, Ohaji Egbema, etc. with materials from the selections which were mostly of the *Dura* type. These early plantings whether in small compound holdings of about 10-100 oil palms, smallholder schemes of 1-10 ha plantations, or the big estates are still very visible and are still being harvested though their productivity has declined tremendously.

The continued exploitation of these old palms is not surprising, considering the fact that the palm tree is highly valued in Eastern Nigeria. Oil palm mills (Pioneer Oil Mills) were also established to improve on the traditional methods of processing palm fruits. The mills were designed to handle *Dura* fruits because of preponderance of *Dura* in the natural groves and in those early oil palm plantations.

In the early 1960s, a more extensive prospection was carried out in the coastal and inland areas of again the eastern part of Nigeria which falls within the center of high diversity of the oil palm. This exercise was extended to Igala area in the northern limits of the oil palm growing areas. A total of 72 open-pollinated progenies were established in an 8-ha genepool at NIFOR in 1964. After evaluation, outstanding palms selected from this genepool were introgressed into NIFOR's main breeding programme.

In 1973, a large-scale prospection was carried out by NIFOR collaborating with MARDI, Malaysia. Samples were collected from 45 locations across the oil palm belt of Nigeria, sampling about 20 palms in each location (Obasola *et al*., 1973). A total of 919 trees (including 515 *Dura* and 325 *Tenera*) were sampled. Over 5411 seedlings (10 per family) were then planted in unreplicated progeny rows in 1975 at NIFOR in a 40-ha genepool. Evaluation of the genepool has been carried out and the materials from the Eastern part of Nigeria clustered in one large group showing outstanding characters. Short palms which are useful for genetically developing the much-desired commercial palms with slow stem growth were also discovered among collections from Eastern Nigeria (Ataga *et al.*, 1999).

In the continued effort to enlarge the genepool, NIFOR carried out another prospection in 1991 in an area generally deemed "marginal" for oil palm production. The area though close to the North-East limit of the oil palm belt in Nigeria falls within the South East zone. The area is known for high-quality palm oil but not covered by previous expeditions. A total of 80 accessions (58 *Dura* and 22 *Tenera*) were collected. Initial characterization of these accessions revealed very interesting bunch and fruit traits (Okwuagwu *et al.*, 1998). It is, therefore, obvious that the collection of oil palm genetic resources in Nigeria has not been exhaustive.

With the development of *Tenera* which is the high-yielding commercial variety, large industrial plantation has become the common production system for oil palm all over the world. In Nigeria, however, this system is small but significant. The smallholder sole or mixed plantations intercropped with a variety of food crops and the natural/semi-wild oil palm groves remain the dominant production systems (Omoti, 2003). It follows, therefore, that any measure to develop the oil palm industry in Nigeria must take this system into account, especially in the eastern part of the country where oil palm production is a major component of the people's farming culture and system.

ACTION PLAN TOWARD FURTHER IMPROVEMENT IN OIL PALM

Improvement of the Productivity of the Groves

Presently Nigeria's oil palm production system is mostly based on natural and semi-natural groves. It is estimated that wild and semi-wild oil palm groves occupy 2.1 million ha of land in the country (Omoti, 2003). Over 80% of this is in the eastern part of the country. The dominance of the natural groves (ca. 91% of the total output) in the production system appears to be one of the major constraints to increasing the country's output. Yields from wild palms which are mostly of the *Dura* fruit form range from 1.0 to 1.5 tonnes of fresh fruit bunch (FFB) per hectare per year. Most of the palms in some farm groves and the wild groves have become old and too tall and less productive. In a few farm groves, due to deliberate human efforts, young productive palms are protected and significant improvements in bunch production are usually obtained though not as much as 18-25 tonnes FFB/ha/year obtained in improved *Tenera* commercial fruit form under appropriate plantation management.

The natural groves are a valued genetic asset in oil palm. As such, improvement of their productivity is considered a veritable tool for the development of the oil palm industry. Studies towards achieving this task are on-going in NIFOR, Benin City of Nigeria, using locations in Eastern Nigeria. Some of the strategies employed are chronicled below.

Systematic introduction of improved *Tenera* commercial planting materials into the groves: These improved planting materials will replace old and tall unproductive grove palms to be felled when the new high-yielding ones come into production. It is expected that the presence of these improved materials in the groves will in the long run have positive effects on the yield of wild seedlings that will regenerate as a product of natural crosses between them and other wild palms. It is estimated that this may improve the productivity of the grove by over 20% over a period of 5-10 years.

Introduction of modern harvesting techniques: There is serious dearth of oil palm harvesters in the oil palm growing region. This is because traditional harvesting technique involves the risky climbing of the tree with locally designed and woven climbing ropes. This is deemed no longer attractive and very few men are willing to undertake such jobs. A large number of bunches are lost due to this technique, and some bunches get rotten on the palms. In modern palm plantations harvesting is carried out with specially designed long harvesting hooks. This technique should be introduced to harvesters in the groves to ensure that ripe bunches are harvested and evacuated to processing sites in good time. Bunches should be harvested and processed at the right time to ensure the production of good quality oil.

Improvement of processing methods: The traditional methods of processing oil palm fruits involve allowing fruits to remain on the harvested and pieced bunches for a number of days to loosen on their own. During this period the oil in the fruits deteriorates resulting in increased levels of undesired free fatty acids, a phenomenon that lowers the quality of the palm oil. Also, the traditional mills with manual screw press are known to have low oil extraction rate (8-10%), as against the modern small-scale palm oil processing equipment (mills) with extraction rate of 13-18% (NIFOR, 2019). The traditional mills are not only of lower oil extraction rate compared with the NIFOR-developed mills, but also few in most areas of the South East, Nigeria, with the zone having a density of < 0.001 mill/ha. To increase the quantitative yields of palm oil and palm kernel oil during the processing of oil palm fruits in this geopolitical zone, there is an urgent need to introduce the efficient NIFOR-developed small-scale mills to the affected areas. In terms of yield quality, the NIFOR-developed mills produce high-quality special palm oil (SPO). These mills, which are affordable and can be conveniently procured by individuals and corporate bodies (cooperatives, town unions or Local Government Councils), are of three categories:

(i) The NIFOR Mini which is a 0.25 tonnes-FFB-per-hour mill, designed for plantation holdings of less than 20 ha, and so ideal for a community with 40 ha of natural palm grove;

(ii) The NIFOR Medium which is a 0.25-0.50 tonnes-FFB-per-hour mill which may cater for over 100 ha of natural grove; and

(iii) The NIFOR Large which can process 1 tonne of FFB every hour. This mill can, therefore, handle bunches from a large community.

DEVELOPMENT OF PALM PLANTATIONS: PROSPECTS, CONSTRAINTS AND RESORT

There are enormous perceived prospects of increased oil palm production in southeastern Nigeria. Strong and efficient palm oil sector in the region will ensure sustainable means of livelihood for its residents thereby enabling the poor to take active part in the fight against poverty (Enwelu *et al*., 2013; Eze *et al*., 2014; Bello *et al.,* 2015). Interestingly, young people in their middle and productive age are interested and actively involved in the oil palm industry in parts of the region (Enwelu *et al*., 2013; Bello *et al*. 2015; Nwankwo, 2016). This spells a bright prospect for the industry. The prospects can extend to the entire Nigeria. Oil palm could serve as a source of revenue for Government and the citizens, as well as raise the standard of living of smallholder farmers. There could be increases in oil palm output/yield if necessary technology is applied, increase in farmers' income, improvement in food and nutrition security, and undoubtedly employment for the teeming population.

However, in especially the South East zone of Nigeria, the failure of the oil palm industry to rapidly grow in response to the desired need dictated by the ever increasing demand and government policies is due to certain constraints. Some of them include (i) difficulty in acquiring large tracts of land owing to land tenure system, huge capital outlay required, lack of incentives and neglect of the rural areas, and inconsistent government policies; (ii) environmental factors - inadequate sunshine and solar radiation, low soil fertility status of the dominant Ultisols vis-à-vis high cost of fertilizers, and unfavourable distribution of rainfall and associated soil moisture stress; (iii) technical aspects including the long gestation period, low and unstable yields, problems with harvesting very tall and over-aged palm trees, the generally low level of management (of weeds, soil fertility, etc.), and poor processing/storage conditions; and (iv) high labour input and cost (Omoti, 2003; Enwelu *et al*., 2013).

Generally the harvesting, processing and storage problems listed under the technical aspects are due to poor infrastructure (Izah and Ohimain, 2016). In the South East of Nigeria, manual harvesting is still predominant (Enwelu *et al*., 2013); so too is the use of primitive processing equipment instead of modern hand-press machines (Bello *et al*., 2015), not to talk of automated oil mill (Nwankwo, 2016). Oil palm production and processing in the region is, therefore, tedious, labour-intensive, and product-wasteful. This is to say that among the constraints enumerated, 'high labour input and cost' has a special place in the zone. To buttress this point, of the three sources of labour input available to the oil palm industry in the zone viz hired labour, family labour and joint efforts of social groups/friends, hired labour is the major source (Enwelu *et al.,* 2013; Bello *et al.,* 2015), contributing over 80% of the total labour requirement (Nwankwo, 2016). This situation implies increased cost of production amidst financial constraint. Financing becomes, therefore, very critical.

Financing has been a major constraint to the growth of the agricultural sector in Nigeria. Most formal credit sources are inaccessible to the mostly small-scale oil palm producers (Bello *et al*., 2015; Izah and Ohimain, 2016). In southeastern Nigeria, the available informal credit sources provide funds at exorbitant interest rates (Enwelu *et al*., 2013; Nwankwo, 2016). Most oil palm farmers here thus fund their production from personal savings, using those in Udi, Enugu State of Nigeria as a case study (Bello *et al*., 2015). This poor funding affects especially the processing subsector. The subsector is dominated by smallholder processors who due to financial constraint mostly practice manual processing (Izah and Ohimain, 2016). For instance, about 80% of the woman processors of palm oil at Awka and Aguata (Anambra State, Nigeria) funded their operations via personal savings which could not fund large-scale production (Nwankwo, 2016).

An additional, largely socio-economic constraint to oil palm development in the South East is high illiteracy level and associated ignorance. Generally, agriculture is synonymous with rural parts of Nigeria as with most developing countries, and the rate of illiteracy is usually high in these areas. Using palm oil processing as an example, the majority of women involved in this task in Nwankwo's (2016) study were reported to have little or no formal education. Such a situation often results to ignorance and hence impaired ability to identify available economic support mechanisms; hence there is reduced access to credit and extension services and low levels of adoption of improved agricultural methods. However, Enwelu *et al.* (2013) in whose study also in Awka area the majority of the respondents had formal education reported that unimproved varieties and natural regeneration still dominated oil palm production in the area. This observation perhaps points back to the aforestated financial constraints to increased oil palm production. For the case cited, it is the cost of establishing new plantations of improved varieties, suggesting that some of the identified constraints could be related.

The major constraints can be ameliorated through deliberate Government intervention not just in the zone, but all over the country. In 2006, the Federal Government of Nigeria put a ban on the importation of vegetable and palm oil into the country to encourage the plantation of palm trees and installation of modern processing equipment (mills) in order to boost the production of palm oil, but this adversely affected both the quantity and the quality of local production (The Nation, 2015a). This situation which implies that the ban had little or no impact on oil palm plantation calls for a review and change of strategy. For Nigeria to regain its prime position in oil palm production worldwide, conscious efforts must be made to expand production via the establishment of large-estate and smallholder plantations. This will create employment, improve the quality of life of the rural populace, and enable the country meet the palm oil domestic demand for food and industrial uses. It is then possible to move from here to even having excess for export.

For instance, if the Governments of the states in southeastern Nigeria can establish schemes for oil palm producers in the region to have access to credit/loan facilities, planting materials of improved varieties and modern harvesting, processing and storage facilities (Enwelu *et al*., 2013), then the prospects of oil palm production in this region can be actualized. The various state governments in the entire country may consider encouraging the Local Government Councils in the rural areas to acquire 10-100 ha of land in each Local Government Area, prepare and plant up the land with improved seedlings currently being raised in each State under the Agricultural Transformation Agenda (Oil Palm) scheme of the Federal Government of Nigeria.

After establishment, interested families will be allocated 1-5 ha each to maintain and exploit. These families will be encouraged to intercrop the plantation with specific crops during the first three years before the palms start fruiting. The families will be made to pay a modest annual rent on the allocation. A NIFOR Large mill will be acquired and installed in each community to buy bunches produced by the families. The mill may be managed by a cooperative body or capable individuals who will refund the cost of procurement and installation of the mill over a period of time.

Under the proposed scheme, appropriate plantation management practices will be enforced by strict monitoring by extension agents. The scheme, if implemented, will create employment, improve the quality of life of the rural populace, reduce poverty and increase production towards meeting at least the domestic demand of oil palm products.

PERSPECTIVES ON OIL PALM ACTION RESEARCH AND DEVELOPMENT

The present status of the exploitation of genetic resources of the oil palm in Nigeria is obviously not exhaustive. There are still abundant natural genetic materials in the wild waiting to be tapped. It is well known among local farmers that there are palms in the wild specially known for their interesting traits such as high bunch number and high bunch weight, high oil yield, twin bunch in one leaf axil, slow stem increment, high palm wine yield, etc. There is need for modern genomics tools to add not only to the basic understanding of the physiology, metabolism and development of oil palm, but also to accelerate breeding of the high-yielding varieties with a tailored oil composition (Barcelos *et al*., 2015). Therefore, the genetically promising materials need to be identified, collected, evaluated and further introgressed into present breeding programmes for both quantitative and qualitative improvements in oil palm. This will tremendously assist toward further exploitation of the potentials of the palm.

There are indications that conversion of forests to oil palm plantations and the resulting alterations of the ecological set-up has negative impact on biodiversity and compromises optimal functioning of the immediate and nearby ecosystems especially in the tropical region (Barcelos *et al*., 2015; Almeida *et al*., 2016; Dislich *et al*., 2017). This increasingly popular view implies that the aforestated ecological benefits of oil palm may not be a match to those due to forests. Though the high-yielding varieties can cushion this impact by sparing the land (Barcelos *et al*., 2015), the impact is not befitting of a tree crop considered a nature's rare gift to mankind with so many benefits cutting across agronomic, ecological, economic and social boundaries. In view of this impact vis-à-vis the multiple roles of oil palm, multidisciplinary research is needed to harness the opportunity

offered by the supposedly complex interactions among the numerous plant and animal species (especially ephiphytic flora and insects) that associate with the oil palm tree and the undergrowths in oil palm plantations, towards making these plantations come at par with forests in terms of ecosystem services.

Agronomic yields often times are a function of crop variety and location. For oil palm, research seems to have focused on genotype × environment interactions on fresh fruit bunch (FFB) and oil yields (Obisesan and Fatunla, 1983; Rafii *et al*., 2001; Okoye *et al*., 2008), not on quality of the palm oil. Fertility status of soils supporting oil palm and water stress could be factors in oil palm production (Woittiez *et al*., 2017). This may be the case too for the quality of palm oil. One aspect of oil palm developments that has largely been neglected by research, therefore, is the exploration of the relationship between the quality of palm oil and the environment with emphasis on soil mineralogical composition and the prevailing humidity. Also, it is a common experience among palm wine tappers that palm wine yield varies with location and season, whereas palm wine consumers often notice that taste varies not only between locations, but also between seasons within a location. As with palm oil, varietal differences alone might not fully explain these quantitative and qualitative variations in palm wine. There is thus need for collaborative, long-term regional studies in this regard.

Beyond the above concerns bordering on research towards improvements in oil palm and enhanced provisioning of ecosystem services, the campaign for increased productivity of oil palm should be carried far and wide and, at the same time, extended down the value chain of this all-important economic tree crop. Some specific suggestions and necessary steps to be taken include:

(i) developing and implementing methods for the sensitization of people in the wild grove areas on adopting appropriate cultural practices and processing techniques for the grove materials to ensure increased productivity;
(ii) leveraging on youth domination of the teeming population especially graduates of agriculture to increase oil palm productivity, by developing a scheme that provides them with incentives to take up oil palm farming as a vocation;
(iii) developing improved cultural practices and processing techniques for grove materials toward enhancing productivity and market value;
(iv) encouraging agro-entrepreneurs to weld into the commercial production of existing products as well as into the downstream industry while making efforts to develop new products; and
(v) guarding against a drop in the production level to be achieved with time, via the establishment of a robust and effective stakeholder-oriented monitoring and evaluation scheme.

To facilitate the achievement of the desired results, there is an urgent national need to create a center of excellence for oil palm in Nigeria, to drive the exploitation and utilization of this nature's endowment to mankind. Besides being the centre of origin of oil palm, South East Nigeria is, according to National Planning Commission of Nigeria, the only geopolitical zone in the country where palm tree processing and palm oil refining are the major economic activities, among others (NPC, 2009). The proposed center of excellence for oil palm should, therefore, be situated in this zone. The ultimate impact of actualizing this proposal would be obvious ecological benefits due to oil palm and improvements in socio-economic wellbeing and livelihood of the people through employment creation, among numerous other benefits. This impact would not only be felt in other geopolitical zones in Nigeria and beyond, but also are expected to reflect in the economy of the country.

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