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Litter production as indicator of nutrients to the forest ecosystem

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Abstract
Nutrient cycling within forest ecosystem depend majorly on the quantity of litter falls due to seasonal plant behaviour and the decomposition of the soil organic matter pool due to biotic and abiotic factors of the environment, the rate of organic matter accretion and the qualities of nutrients supplied from external sources. The biomass inputs to the soil ecosystem may be balanced with the mineralization rates so that ecosystem exists in equilibrium. This study seeks to review litter production as critical indicator of nutrients to the forest ecosystem within the context of the following sub-themes: types and sources of leaf litter, seasonality of leaf litter production in the tropical forest, pattern of litters' production in the forest ecosystem uses of leaf litter production, restoration of land degraded site/erosion, uses of leaf litter production on growth performance of forest species and types of nutrients disposed. The study conclude by re-emphasizing litter production and decomposition as key processes in biogeochemical process of forest ecosystem; and this varies with climate, season, substrate quality, and type of biodiversity. The study recognizes forest plantation as the major pathway for recycling of nutrients in soil system through litterfall or litter production.

Keywords: litter production, indicator, nutrients, forest ecosystem

Introduction

Transformation and movement of materials within soil organic matter pools is a process influenced by climate, soil type, vegetation and soil organisms (Ajah 2006). The cycles involve both physical (dissolution, precipitation, volatilization and fixation) and chemical (synthesis, degradation and oxidation-reduction). It is possible to trace the cyclic movement of these essential chemical elements through the biosphere and by so doing; much can be learned about the interdependencies that exist. Forests improve the microclimate by reducing the change caused by wind, protection against soil erosion and restoring soil productivity. Tree crops result in significant improvement in soil fertility through the addition of plant litter, nutrient cycling, biological nitrogen fixation, permeability, and water holding capacity, aggregate stability and soil temperature regimes (Aluko, 2001). Deforestation results in changing the status of the forest soil. In tropical rain forests, certain tree species are found to exert considerable influence on soil properties (Lal *et al*., 1975). Lal *et al*., (1975) stated that soil nutrient status could be improved through nutrient cycling in terms of litterfall, litter decomposition and mineralization. This phenomenon cannot occur without forest cover. Forests, especially protected, ensure environmental sustainability and conserve biological resources for future generations (Thies and Pfeil, 2004).

Plants irrespective of the class, as living organism exhibit biological characteristics such as: reproduction, nutrition, irritability, respiration, growth and death. Despite all these characters by plants in its habitat, plants growth is dynamic and continuous process. Plants generally grow both in natural habitat/forest and forest plantations in the tropics. Every stage of growth in a tree involves formation of new leaf or leaves which lead to increment in morphological attributes, such as: height, girth, leaf production and root elongation. Leaf production in plants plays a very unit role in the life of the tree as well as forest soil/floor ecosystem. Leaf litter production and decomposition are key processes in biogeochemical process of forest ecosystem and varies with climate, season, substrate quality, and type of biota (Bisht *et al*., 2014) [9]. The condition of plant habitats affects leaf litter production. Forest plantation establishes the major pathway for recycling of nutrients in soil system through litterfall or litter production (Bubb *et al*., 1988) [13]. Fast growing exotic plant species are used for soil erosion control, leaf litter production and for fuel wood production in Nigeria (Ogbonna and Nzegbule, 2010). According to Manuel *et al.*, (2005) [28], plant litter comprises:

a. dead leaves, bits of barks or other plant matter;
b. mixtures of fallen and dead materials on the forest floor which are made up of leaves, barks, stems and branches;
c. leaves that have fallen from a plant due to seasonal changes or diseases.

Clarke and Paul (1970) [16] described plant litter as non-living materials, morphologically recognizable as of plant origin, composed mainly of dead parts and other fallen plant organs lying on the surface of the soil but not standing dead matter. Leaf litter is the main shelter for small animals which include insects, centipedes, isopods and other micro- organisms.

Leaf litter on the soil surface intercepts and stores a certain amount of rainfall and hence reduce run - off and soil erosion on the forest floor. On the forest floor, litter is the imperative link between the autotrophs and heterotrophs (Bray and Gorham, 1964) [10]. It reduces bulk density, increases water holding and cation-exchange capacity of soil and serves as reserve store of plant nutrients (Ogbonna and Nzegbule, 2010 and Longman, 2007) [27]. Forest litter is an important stage in habitat conservation providing nutrient return and organic matter replenishment (Ogbonna *et al.*, 2010). The standing state of litter provides an estimate of the net production of the vegetation. Besides having enormous utilities to the ecosystem, the litter paradox yet needs to be explored.

Types and sources of leaf litter

Debris from primary producers (plants) accumulates on the surface of the soil and also within the mineral horizons along the network of roots and rhizomes (Dickinson, 1974). Some of the litters are incorporated inside the soil primarily through the activities of earth worms and termites. Litter types comprise barks, flowers, leaves, seeds, fruits, small twigs and small branches of plants which are the bulk of litter that enters the soil in most vegetation (Clarke and Paul, 1970; Dickinson, 1974, Okeke and Omaliko, 1994) [16]. Non-leaf litter components of plant litter form about 21% of the total litter produced (Dickinson, 1974). Okeke and Omaliko (1994) and Dickinson (1974) also noted that other sources of litter entering the soil include the following:

a. forest ecosystem consisting of tropical rainforest, mangrove forest, swamp forest, evergreen forest land, deciduous forest, etc;
b. grass litter comprising savanna grassland, guinea savanna, grass floor, range land, etc;
c. plantation floor litter, forest plantation, agroforestry plots;
d. bush fallow floor litter;
e. arable land (plant/crop residues, weeds).

Seasonality of leaf litter production in the tropical forest

It is a common phenomenon that leaf litterfalls throughout the year in most trees, and that majority of trees shed more of their leaves during the dry season, rather than the wet season. According to Ogbonna and Nzegbule (2010), although litter falls throughout the year, there is usually a distinct seasonal trend, with much of the litter falling between March and April particularly in the pure *Pinus caribeae* stand. The months of March and April are within the dry season which is characterized with low relative humidity, and great fluctuations in diurnal temperatures (Ogbonna and Nzegbule, 2010). The seasonal characteristics probably favour the increase in litter fall. In pure *Gmelina arborea* stand, litterfall peak is in the month of September. This trend is due to heavy rainstorms that promote dislodgement of more litter materials.

Agroforestry system is characterized by selective thinning of the forest prior to the establishment of utilizable forest food seedlings, for example, cacao (cabruca) (Rice and Greenberg, 2000). The peak period of litterfall in cabruca systems corresponded to the leaf-drop cycle of cacoa trees in October. Forest systems also experience peak litterfall from October through December, in accordance with the observations of native forests by Mori *et al.* (1983) [32]. Litterfall and litter accumulation are usually continuous throughout the year in the tropics, but are often characterized by seasonal peaks (Okeke and Omaliko, 1994). This implies that there is a relationship between the time of highest wind speed, associated with the dry season and also period of highest rate of litterfall accumulation in the forest.

Pattern of litters' production in the forest ecosystem

The pattern of litter production varies from plantation to plantation, and also from species to species. Polgkase and Attiwill (1992) [43] noted that the differences are attributed to the species composition of the stand which influences the pattern and quantity of litter and characteristics of litter. Evergreen forest vegetation, for example, pine plantation, produces more litter than deciduous forest vegetation (Vogt *et al*., 1986) [53].

This shift is important to understand leaf litter production patterns along forest development stages and environmental gradients. For example, based on several studies in litter production from world forests, Bray and Gorham (1964) [10] and Albrektson (1988) [3] noted that annual litter production increases rapidly during stand development until canopy closure, and then remain relatively constant over a long period of time before it decreases in old stands. Xiao *et al*. (1998) [56] had earlier used data on litterfall and its relationship to environmental variables to calibrate the terrestrial ecosystem model (TEM) for assessing the sensitivity of net ecosystem production of the terrestrial biosphere to transient changes in atmospheric CO_2 concentrations and climate. The monthly litterfall production pattern is mainly controlled by community characteristics and environmental factors. Seasonal changing in pattern of productivity is correlated with climatic factors prevailing in the zone (Zafar *et al*., 2012) [58]. The seasonal pattern of litterfall differs among forests but a consistent pattern of bulk litter fall during spring is found for all forests (Yu *et al.*, 2005).

Causes of litters production in forest ecosystem

According to Ogbonna *et al.* (2010), Okeke and Omaliko (1994), Bruederie and Streans (1985), Escudero *et al*. (1985) and John (1973), the major causes of litter production in the forest ecosystem are listed below:

a. defoliation- defoliating caterpillar and herbivorous insects – which enhance leaf abscission and litterfall respectively;
b. climatic variables such as temperature, pressure, rainfall, wind, sunshine, and humidity;
c. physical disturbances to forest, such as storms and fire which induce pulse of litterfall;
d. floristic composition, stand age, tree management and stocking;
e. leaf abscission and leaf senescence;
f. f. water stress which triggers build-up of abscissic acid in foliage of plants and stimulates senescence of leaves and also other parts of the plant;
g. environmental factors such as water and nutrient availability;
h. h. edaphic and physiological factors which may affect the pattern and quantity of litter production in the year.

a. Defoliation

Defoliation by forest herbivores is a common forest disturbance that affects all trees in the forest either directly or indirectly (Escudero *et al*., 1985). Loss of leaves dramatically decreases photosynthetic rate, and, therefore, sharply reduces the quantity of photosynthate a tree produces. Since transpiration occurs in leaves, defoliation also reduces the quantity of water a tree uses. Because soil nutrients are absorbed by roots and distributed throughout the tree in dissolved form, nutrient uptake would also be affected. The effects of defoliation may vary among tree species due to their specific physiological needs and abilities, and also to vary in their attractiveness to herbivores.

Defoliating caterpillar and herbivorous insects enhance leaf abscission and litterfall respectively (Escudero, *et al.*, 1985). The pine brown tail moth (*Euproctis terminalis*) is a major defoliating pest of *Pinus* species. Caterpillars are wasteful feeders as they feed on the basal part of the needle, with the remaining part of the needle falling to the ground. An abundance of green needles on the forest floor often indicates the presence of this insect.

b. Climate change

Microbial decomposition of plant litter and soil organic matter sustains ecosystem productivity by cycling carbon, nitrogen, and other nutrients (Davidson *et al*., 2000). Decomposition, in turn, is primarily controlled by climate and plant litter chemistry. The climate that sustains plant growth and decomposition is rapidly changing; Earth's average surface temperature is projected to increase by 1.4–5.8ºC by the end of this 21st century (IPCC, 2007). At the same time, rainfall events are expected to become less frequent and more intense, resulting in longer, more frequent periods of drought. These changes could directly affect nutrient cycling in the ecosystem by affecting the chemical composition and, thus, the decomposability of litter produced. As the efflux of carbon iv oxide (CO_2) via microbial decomposition of organic matter content is a significant component of the global carbon cycle (Davidson *et al*., 2000), the climate-induced change in litter chemistry could alter the global carbon budget as well.

Climatic factors, such as temperature, pressure, rainfall, wind, sunshine, and humidity, also cause litter production. The influence of litter production by climate change is still relatively unknown. Although warming may increase litter production, acidity reduces litter production, and the combined effects of the two processes will determine the result of changes and the direction of the trend (Tóth *et al*. 2007; Kotroczó *et al.,* 2007). The litter production changes can also affect climate change due to drought-induced forest boundary shift towards the poles (Mátyás 2010). Litter production is, therefore, controlled by climate and edaphic factors (Meentemeyer *et al*., 1982).

c. Physical disturbance to forest ecosystem

Physical disturbances to forest, such as storms and fire, induce pulse of litterfall (Bruederle and Streams, 1985). Disturbances are a natural part of every ecosystem. Ami *et al.* (1995) noted that some disturbances, such as forest fires, and other natural disasters are quite dramatic, small parasitoid and herbivore outbreaks can cause major disturbances in an area. In many cases, disturbances may affect different organisms differently. Ami *et al.* (1995) also noted that resource availability, resource utilization, growing conditions and many other factors influence ecosystem functions; disturbances have the powerful capability of altering any or all of these factors.

d. Stand structure and changes in stand community structure in the forest formation

Ukonmaanaho *et al*. (2008) state that the vegetation composition of boreal coniferous forests comprises a tree layer, an understorey of dwarf shrubs, a ground layer of mosses and lichens, tree litter, its quantity and chemical properties, and the impact of the litter on the forest ecosystem's ecological processes, such as decomposition, formation of humus, and nutrient cycling. Changes in the plant community structure of the understorey and forest floor of coniferous forests can cause significant changes in the quantity and quality of litter, and consequently have a direct impact on soil accumulation (Hättenschwiler and Gasser 2005). Changes in the litter layers` microbial community structure and decomposer community occur on account of changes in the plant community (Allison *et al*., 2009). Changes in the species composition and activities of the decomposer community have an indirect impact on the accumulation of organic matter.

e. Mechanism of leaf abscission and leaf senescence

In the process of leaf abscission, plants periodically shed their leaves. Leaf abscission involves a number of biochemical and physical changes that are largely controlled by plant hormones. Mechanisms of leaf abscission and leaf senescence are other factors that affect litter fall (John, 1973). Leaf abscission occurs at the base of the petiole that is internally marked by a different zone of few layers of thin-walled cells arranged transversally across the petiolar base. This region is termed the abscission layer or the abscission zone. Abscission, like senescence, is a natural order of progression during the life cycle of most plants. Although the process is closely correlated with regular seasonal changes, variations in environmental conditions can enhance abscission (John, 1973). The cells of the abscission layer are different from each other because of the dissolution of middle lamella and the primary cellulose walls beneath the influence of the raised activity of the pectinase and cellulose enymes. At this phase, the petiole remains joined to the stem only by vascular elements.

Following senescence, abscission of the leaves inevitably takes place. This process usually involves the formation of an abscission layer at the base of the leaf petiole. During the early life of a leaf, auxin is produced in relatively high concentrations and is steadily transported out of the leaf through the petiole (John, 1973). As long as the auxin level remains high in the leaf and a sufficient amount of the hormone is transported across the petiole, both senescence and abscission are delayed. Gibberellins and cytokinins are also produced elsewhere in the plant and then sent to the leaves to help retard the destructive processes. As the leaf matures, however, the level of the senescence-retarding hormones, especially auxin, decreases (John, 1973).

f. Water stress

Water stress can trigger synthesis of abscissic acid in foliage of plants and also stimulates senescence of leaves and other parts (Ogbonna and Nzegbule, 2010). Soil organic matter levels increase as mean annual precipitation increases. Conditions of elevated levels of soil moisture content result in greater biomass production which provides more residues, and, thus, more potential food for soil biota. Soil biological activity needs air and moisture for action. Optimal microbial activity occurs at near "field capacity", which is equivalent to 60-percent water-filled pore space. On the other hand, periods of water saturation lead to poor aeration. Most soil organisms need oxygen, and thus a reduction of oxygen in the soil leads to a reduction of the mineralization rate as these organisms become inactive or even die. Some of the transformation processes become anaerobic, which can lead to damage to plant roots caused by waste products or favourable conditions for disease-causing organisms. Continued production and slow decomposition of leaves can lead to very large organic matter contents in soils with long periods of water saturation (Okeke and Omaliko, 1994).

In natural humid and sub humid forest ecosystems without human disturbance, the living and non-living components are in dynamic equilibrium with each other (Bruederic and Streans, 1985). The litter on the soil surface beneath different canopy layers and high biomass production generally results in high biological activity in the soil. Okeke and Omaliko (1994) and Ogbonna *et al.* (2010) reported that the litter on the soil surface distinguishes the following mechanisms:

a. continuous soil cover of
b. living plants which, together with the soil architecture, facilitates the capture and infiltration of rainwater and protects the soil;
c. a litter layer of decomposing leaves or residues providing a continuous energy source for macro- and micro-organisms;
d. the roots of various plants distributed throughout the soil at different depths which permit an effective uptake of nutrients and an active interaction with microorganisms;
e. the major period of nutrient release by micro-organisms which coincides with the major period of nutrient demand by plants;
f. nutrients recycled by deep-rooting plants and soil macro and micro fauna.

This equilibrium creates almost closed-cycle transfers of nutrients between soil and the vegetation adapted to such site conditions. The equilibrium also results in sound physical and hydrologic conditions for plant growth, i.e. a cool microclimate, increased evapotranspiration, good rooting conditions with good porosity and sufficient soil moisture. This facilitates water infiltration and prevents erosion and runoff. The equilibrium results in clean water in the streams emanating from the area, a relatively smooth variation in streamflow during the year, and recharge of groundwater.

g. Environmental factors such as water and nutrient availability:
To properly grow into profit- making crops, plants require a certain environment (Carrol *et al.,* 2011). The environmental factors that have the greatest effects on plants are water, nutrition, medium, temperature, light, humidity, insects and diseases. Plant litter production and decomposition is a crucial ecosystem process that defines and governs the plant-soil relationships by regulating the nutrient turnover and the build-up of soil organic matter (Chakravarty *et al*., 2019). Plants that grow in areas with low nutrient availability tend to produce litter with low nutrient concentrations, as a larger proportion of the available nutrients are reabsorbed. Litter is the principal source of organic matter for soils in the forest ecosystem. The litter production and decomposition, makes available essential nutrients for the growth and development of a forest stand structure. Different components (root, stem, leaves, twig, flower and bark etc) of the species contain different amounts of nutrients and build-up of soil organic matter. The amount of nutrients added through litter decomposition varies with forest types, species, stand attributes, and variation in seasonal environmental conditions. Nutrient return from organic matter is estimated by the physico-chemical properties of the litter. Moreover, the rate of decomposition and the nutrient releases are highly influenced by magnitude of litter produced, litter quality and nutrients release, as well as, by climatic conditions and existing microbial communities in the soil system. Ecological impact of carbon and nutrient dynamics in the litter layer is considerable in a forest ecosystem.

Soil, litter and plant organ analysis is not an efficient tool for monitoring nutritional status of vegetation. Presence of mineral elements gives good information towards the knowledge of nutrient cycling and biochemical cycle in the soil-plant ecosystem. The presence of nutrients in the soil does not mean that the tree or vegetation is satisfactorily nourished. The availability of nutrients to the tree is conditioned by the content of water in the soil, soil aeration, soil temperature, soil microorganisms and the efficiency of the root system to absorb nutrients (Raij, 1981). Proper soil management and forest nutrition is the basis for the availability of the nutrients and maintaining the productivity of planted or natural forests (Alvarado *et al*., 2014).

h. Edaphic and physiological factors which may affect the pattern and quantity of litter production in the year.
The type of soil and associated edaphic factors in terms of micro and macro-organisms affects nutrient contents and availability in the forest floor. The impact of these will be reflected on biomass within the environment. The performance of any tree/plant is anchor on the percentage of soil compositions and this depends on the soils origin. Some soils were formed as a result of the breakdown of rocks over thousand years, while others developed as certain materials were deposited by water (Carrol and Reiley, 2011). However, any of this process of soil formation has a greater influence in leaf litter production in an ideal ecosystem which affects the supply of plant nutrients.

Uses of leaf litter production

Naturally litterfall covers the soil and reduces the impact of raindrops, improves soil structure, increases soil nitrogen content and enhances nutrient retention (Fassbender *et al.*, 1991; Beer *et al*., 2003). The litter and organic matter protect the mineral soil from raindrops by absorbing the impact energy of droplets. Once on the forest floor, water can move through it and into the mineral soil below. In the absence of an intact forest floor, the quantity of raindrops that hit and expose mineral soils have sufficient force on the surface to compact the soil slightly (Otorokpo, 2012). Tiny particles also become dislodged and then fill in the pores' around neighbouring soil particles. The combination of direct raindrop compaction and pores filing reduces infiltration rates and increases overland flow, possibly leading to erosion (Stuart and Edwards, 2006).

Leaf litter has long been recognized for its importance in the nutrient dynamics of plant communities. Leaf litter can reduce diurnal and annual thermal amplitude in forest by reducing the amount of solar radiation reaching the soil and by providing insulation for the soil (Otorokpo, 2012). Soil moisture is typically greater and flunctuates less under leaf litter than when bare. Large patches of litter have been found to have greater soil organic matter and lower soil bulk density than smaller little patches (Kostel- Hughes *et al., 2005*).

Restoration of land degraded site/erosion

Land degradation, a decline in land quality caused by anthropogenic activities, has been a major national and international issue in recent times. There is widespread evidence of environmental degradation caused by destructive impact of human activities on natural resources (Kadeba, 1990). The rural populations have consequently become vulnerable to hazards such as drought, desertification and economic adversity. Land degradation results in lowering of both land surface and quality of the soil with due consequences for plant growth, in particular, and the entire ecosystem in general (Oke, 2001). Litter layer along with ground vegetation is the most source of protection for the soil surface (Otorokpo, 2012). Litter acts as a natural blanket of mulch, which controls soil moisture and temperature (Brown, 2010). Raindrop erosion increased from 10 to 90 times depending on rainfall intensity under *Shora rosbusta* forest where the litter had been lost through burning (Evans, 1992). The presence of litter and undergrowth alone virtually eliminated soil in *Acacia auriculiformis* plantation with or without a tree canopy (Weirsum, 1983). The dense needle mat under pine plantation in Jamaica was even better than the rain forest in minimizing surface soil erosion (Richardson, 1982). Litter and humus layers protect the soil from the direct impact of the raindrop, absorb moisture, slows the movement of water into the soil (infiltration rate) and reduces soil water evaporation. In a 7-year-old mixed species stand in south-eastern Bahia, Brazil, uniform litterfall rates provided a more effective soil cover (Antonio *et al.*, 2007).

Quite about from the causes of litter production enumerated above, incident of bush fire, lightening and storm also induces accumulation of leaf litter in most forest floor, especially in young plantation like in the case of exotic species (*Tectona grandis* and *Gmelina arborea*). Most forest managers always adopt or deliberately set fire on their plantation annually, to ease cleaning-up of the forest, addition of nutrients to the soil and to trigger growth among the species within the ecosystem. In the Western part of Nigeria, *Tectona grandis* plantation in Oni-gambari along Ije-Pude/ Ibadan Highway has been witnessing annual bush burning, this exercise had impacted positively on the plantation, in terms of morphological features of the plants. This always led to the formation or production of biomass by trees, which later on shed on the forest soil.

Lightening and storm are natural phenomenon that occurs mostly during on-set of rainfall and during the winding-up of rainfall, which is March–April and October–November respectively in the Southern part of Nigeria, though occasionally it can equally happen within other periods of the year. Sometimes, when lightening and storm took place within forest estate, it's normally caused partial destruction of trees. For instance, in Swamp Forest Research Station, Forestry Research Institute of Nigeria (FRIN), Onne - River State, Nigeria lightening and storm struck on *Entandrophragma angolense* and *Pinus carribeae* in April 2019, which eventually resulted in partial destruction of the species. The effect of the partial destruction lead to accumulation of different component of litters on the floor, which will in turn increase humus content and soil fertility through litters decomposition.

Uses of leaf litter production on growth performance of forest species

Litterfall and litter decomposition from trees are important factors that contribute to soil quality (Wedderburn and Carter, 1999). A healthy soil web breaks leaf litter into a rich, organic layer that supports life both above and below the soil surface (Strader, 2009). Antonio *et al.* (2007) explained that the growth and yield of forest species are due to constant litter fall rates throughout the year. The variable rates of nutrient transfer through litterfall, the diverse quality of the litter component which leads to a more uniform decomposition rate, and the complementary roles of the different species in nutrient uptake result to improved soil fertility. Continuous litterfall rate in a young forest plantation results in large tree diameter, height and above ground biomass (Montagnini *et al.*, 1994). Adegeye *et al.* (2010) as cited by Adeola, (2015) reported the beneficial effects of tree-based system on soil in an agroforestry ecosystem as shown in Table 1.

Table 1: Beneficial effects of tree-based agroforestry system

Nature of process	Processes/avenues	Main effect on soil
INPUT (augment additions to soil)	Biomass production (litter and root decay) -Nitrogen fixation -Effect on rainfall (quantity and distribution)	Improvement or maintenance of organic matter N- enhancement Influence on nutrient addition through rain /dust
OUTPUT (reduce losses from so il)	Protection against wind and water erosion	Reduce loss of soil and nutrients
TURN –OVER	Nutrient retrieval/cycling/ Release	Uptake from deeper layers and deposition on surface
"CATALYTIC" (indirect influences)	Physical Chemical Microclimate	Withholding nutrients that can be lost by leaching -Improvement of soil properties Moderating effect on acidity, salinity and alkalinity Ameliorative effect on extreme conditions of microclimatic.
	Biological	Effect on soil microorganism improvement of litter quality through species diversity

***Sources*:** Nair (1991); Nsien (2010); Adegeye (2010) and Adeola (2015b)

Agroforestry has considerable potential as a major land-arrangement system for conserving soil and maintaining soil fertility and productivity in the tropics (Nair, 1993). This belief is based on the hypothesis, supported by scientific data, that trees and other vegetation improve the soil beneath them. Observations of interactions in natural ecosystems have identified a number of points which support the hypothesis (Nair, 1993) stated below:

- From time immemorial, farmers have known that they will get a good crop by planting in forest cleared areas;
- Soils that develop under natural woodlands and forests are well structured, with moisture-holding capacity and high organic matter content;
- Unlike agriculture systems, a forest ecosystem is a relatively closed system in terms of nutrient transfer, storage and cycling;
- The ability of trees to restore soil fertility is illustrated by experiences in many developing countries, which indicate that

the best way to reclaim degraded land is through afforestation or a similar type of tree-based land-use;

- The conversion of natural ecosystems to arable farming systems leads to a decline in soil fertility and a degradation of soil properties unless appropriate and often expensive, corrective measures are taken;
- The micro-site environment qualities of trees have long been recognized in many traditional farming systems.

Soil organic matter and nitrogen contents are significantly higher in certain woody species than in the surrounding soil. Addition of organic mulch favourably affects the soil physical parameters. Mulching via periodic pruning lowers soil temperature, reduces temperature fluctuations and increases moisture infiltration and retention (Okeke, 2010). The increase in soil humus and organic matter level under alley farming, due to addition of prunning, crop residues and litterfall also enhances soil biotic activities as measured by increased biomass carbon. Therefore, leaf litter and prunning from hedgerows can provide large amounts of organic matter and increase nutrient levels. Pruning of trees, shrubs and natural litterfall in agroforestry ecosystems cover the soil and reduce the impact of rain drops, as well as increase soil moisture infiltration and retention rates. Water fluctuation between the rainy season and dry season is consequently significantly different. Agroforestry also improves soil structure, increases soil nitrogen contents and enhances nutrient retention, thereby making the soil suitable for arable crops (Oke, 2001).

Maintenance of soil productivity is particularly important because of the close link between productivity and plant production. Agroforestry has a role in the process of soil organic matter build-up through decomposition of leaf and twig litters. Litter decomposition is not only the main source of energy, and nutrients for soil and litter organisms but is also the major pathway for recycling of nutrients for plant communities, especially in soils of inherently low fertility (Oyebade and Oddo, 2004).

Types of nutrients disposed

Mineral elements are required for normal growth and development of green plants (Umeh, 2009). In addition to carbon (C), oxygen (O) and hydrogen (H), other mineral elements which green plants need in form of salts in large quantities are: potassium (K), nitrogen (N), phosphorus (P), sulphur (S), magnesium (Mg), calcium (Ca) and iron (Fe). All these are referred to as essential major or macro nutrients (Tisdale, 2003). Other minerals such as: manganese (Mn), zinc (Zn), copper (Cu), boron (B), molybdenum (Mo) and chlorine (Cl) are referred to as non-essential, minor or micro nutrients. Mineral elements are absorbed from the soil in solution through the roots of plants. It is natural that, if any of the macro or micro-nutrients is absent from the soil, plants may show poor growth. When plants are deficiency in these mineral elements both vegetative and yield will be very low especially biomass formation.

Conclusion

Plants generally grow both in natural habitat/forest and forest plantations in the tropics. Every stage of growth in a tree involves formation of new leaf or leaves which lead to increment in morphological attributes. Leaf production in plants plays a very unit role in the life of the tree as well as forest soil/floor ecosystem. Leaf litter production and decomposition are key processes in biogeochemical process of forest ecosystem and varies with climate, season, substrate quality, and type of biota (Bisht *et al.*, 2014) [9]. The condition of plant habitats affects leaf litter production. Forest plantation establishes the major pathway for recycling of nutrients in soil system through litterfall or litter production.

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