IJRCE

International Journal of Research in Chemistry and Environment
Vol. 3 Issue 1January 2012(44-51)
ISSN 2248-9649

Research Paper

Seasonal Variation in Litter Fall an Age Series *Gmelinaarborea* Plantation in a Nigerian Rainforest

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(Received 16th May 2012, Accepted 20th October 2012)

Available online at: www.ijrce.org

Abstract: *Monthly variation in litterfall of Gmelinaarborea stands aged 28, 29, and 30 years were studied for 13 months in 2005 - 2006 with litter traps in three 20m x 20m plots randomly selected in Gmelinaarborea stands in Shasha Forest Reserve (SFR), Osun State, Nigeria. Monthly collections of litter fractions per stands were sorted into leaves, twigs, reproductive structures and others. Litters according to fractions per stand per month were oven dried at 80°C for 48 hours. Samples were created for chemical analysis. Data collected were analyzed using descriptive statistics and inferential at 0.05 level of significance. Litterfall (especially leaf fall) occurred throughout the period of collection(13 months) in the stands(S). The peak of total litter fall was recorded in October 2005 in S_1(18.2%) while peaks were recorded in September of same year in S_2 (11.21%)and S_3 (13.67%). The analysis of variance to determine interaction effect between fall of the litter fractions and age of the stands did not show any significant differences. Leaves constituted the bulk of litter fall across the three stands. The percentage of leaf litter to the total litter per hectare in stand ages 28, 29 and 30 years were 41.32, 34.19 and 24.48% respectively, while the contribution of unidentified litter thrash was highly insignificant.*

Keywords: Shasha Forest Reserve, Nigeria, Litterfall, Age series, Nutrient dynamics, Seasonal variation.

Introduction

The study of litterfall in any forest ecosystem is an essential step in the study of ecosystem productivity. The importance of litterfall and decomposition in a forest ecosystem cannot be overemphasized because they form the basis for nutrient availability and recycling between soil and the standing trees. The maintenance of satisfactory growth in a forest ecosystem is dependent on the recycling of essential elements through litterfall and decomposition.

The quantity and composition of litter have been measured in a number of tropical communities and the results have been summarized [1,2]. They reported about 10,200 – 12,300 kg/ha for tropical rainforest. Nye (1961) and John (1973)[2,3] recorded about 10, 540 kg/ha and 9,660 kg/ha for semi–deciduous forests of Ghana respectively. Also, litterfall in other African forests according to John (1973)[2] varied from 8,260–13,370kg/ha in Cote – d'voire and 11,000 – 13,200kg/ha in Yangambi (Democratic Rebuplic of Congo).

The amount and composition of litter within Nigerian forest ecosystem have also been estimated. Hopkins (1966)[4] recorded about 7,170kg/ha for Omo – Forest Reserve and 4,720kg/ha for Olokemeji Forest Reserve. Nwoboshi (1978)[5] reported about 7,450 – 7,765kg/ha for Sapoba Forest. Ewel (1976) and Nwoboshi (1981a) [6,7] noted that litter production increased with age and thinning intensity. The amount of litter fall in unthinned and thinned stands of *Tectonagrandis* varied from 350kg/ha (7,631 stem/ha) to 5,273kg/ha (2,224 stem/ha). It was reported that the amount of litter fall, nutrient content and season of fall did not reflect differences in stocking density [5].

The pattern of litter fall varies with species and the climatic regimes in the area. Generally litter falls throughout the year but the monthly mean rates of production of individual litter components and total litter do not necessarily correlate with the monthly mean temperatures or monthly total rainfall[8]. John (1973)[2]

showed that leaf fall is mainly seasonal while woody litter production is usually continuous and largely governed by physiological processes. Nwoboshi (1985b)[9] found that litter falls throughout the year in teak plantation and Songwe *et al.* (1988)[10] found the same trend in the tropical rainforest. Also, Landelout and Meyer (cited by Ojo 2005)[11] studying litter fall in Yangambi (Zaire) showed that there was low litter production during the rainy season, while Nye (1961)[3] noted that litter fall in most tropical forest in Ghana was continuous and that during the short dry season, January to February, there was higher litter accumulation in February.

Litter fall therefore constitutes one of the major path–ways in the bio–geochemical cycle of terrestrial ecosystems in the lowland tropics. It has been shown that a large proportion of annual litter fall (especially leaf litter) decomposed within a year, usually between 2–5 months [2,3,4,12,13] thus releasing minerals to be absorbed by the plants or to be lost to the ecosystem by leaching and runoff. Litter fall can then be described as an important waste in a forest ecosystem. It is an indispensible component in the perpetuation of the physiological and bio -ecological processes in the forest. It is a major pathway in the energy and nutrient transfer in a forest ecosystem. It serves as a source of nutrients for various micro-organisms responsible for the release of nutrients and thus, increase the water holding capacity of the soil[14]. Admittedly, litter fall and decomposition form the greater part of nutrient net production in the forest.

Material and Methods

Study Area: This study was carried out in the *Gmelinaarborea* plantations in Shasha Forest Reserve (SFR), Osun State Nigeria in year 2005 and 2006. The reserve is located between Lats 7^0 and 7^0 3^0 N and Long 4^0 and 5^0 E. The total area of the forest reserve is currently 23,064ha out of which, 1,523ha is under plantation of species such as *Gmelinaarborea, Tectonagrandis, Terminalia*species, *Latin binomial* and *Nucleadidderrichii*. The total annual rainfall ranges from 887mm and 2180mm. The mean annual temperature is 26.5^0C with the annual range between 19.5^0C and 32.5^0C. Soil types are generally deep to very deep, well drained and composed of loam, sandy loam, loamy sand and sandy clay – loam[15]. Though, Bada (1977)[16] and Kio (1978)[17] described the geology and soils of the Forest Reserve as composed of undifferentiated crystalline rocks (basement complex). The 1976, 1977 and 1978 *Gmelinaarborea* plantations are 40, 40 and 35 hectares respectively.

Methods of data collection

Selection and Demarcation of Plots: Reconnaissance survey of the study area was carried out in August and December 2004 and February 2005 for the purpose of establishing experimental plots. Nine (9) plots (three plots) per stand of 20 x 20 –m (0.04) ha, were selected randomly from 1976, 1977 and 1978 stands. The sample plots were delimited with pegs and the boundary cleared. Three sampling units were randomly selected in each stand (i.e nine plots in three stands with approximately 10m intervals between each plot). In each selected plot, five litter traps were randomly located. The litter traps were made of wooden frame (1mx1m), 10cm (thickness) and plastic mesh base (1mm) to allow free passage of rain water. To avoid the decay of litter after being trapped, each litter trap was raised on four (4) wooden legs 40cm above the ground.

The litter in each 1m x 1m litter trap (30cm) deep was collected at fortnight intervals for thirteen months. The litter removed from the litter traps were spread out on large plastic sheets and later sorted into the followings, leaves, twigs, foliage(R/S) and other (unidentified litter). The litter fractions were air – dried in a ventilated room for one week at the reserve before being enveloped and transported to the Department of Forest Resources Management Laboratory, University of Ibadan. The litter fractions per stand were bulked, oven – dried at 80^0 C for 48 hours to constant weight and weighed separately. After weighing, monthly bulk samples were then created for each fraction in each stand.

Methods of data analysis

Data collected were analyzed using a combination of analysis of variance (ANOVA), correlation analysis and multiple linear regressions. The period of the year being the independent variable, the functional relationships of time to observed litter fall were carried out, where the value for time (month) based on the period of assessment. Total litter fall is therefore expressed as a function of time (t), t^2 the natural log of time $(Int)^2$ in various combinations of total litter fall, leaf litter, twigs, reproductive structures, time (t), Time squared (t^2), natural log of time (Int) and natural log of time squared $(Int)^2$.

Results and Discussion

Litter fall: The percentage monthly litter fall ($Kgha^{-1}$) for the three stands in the study site is presented in Table 1, the result of analysis of variance (ANOVA) of litter fractions ($Kgha^{-1}$) for the 3 stands is presented in Table 2, while the mean annual litter fractions for the three years is presented in Table 3. Litter fall (especially leaf fall) occurred throughout the period of collection (13 months), in the stands (S). The peak of total litter fall was recorded in October 2005 in S_1 (18.2%) while peaks were recorded in September in S_2 (11.21%) and S_3 (13.76%) in 2005 (Table 1). The analysis of variance to determine interaction effect between fall of the litter fractions and age of the stands did not show any significant differences. Leaf litter had the highest contribution to the total litter fall in all the ages. While the contribution of unidentified litter thrash was highly insignificant. The analysis of variance for all the litter fractions followed the same trends.

Similar trend was noticed in S_1 and S_2 in February 2006 (S_1 14.35%, S_2 20.25%) but marked decrease was recorded in S_3 at the same period (9.30). The major peaks were related to the dry period when there was little or no rain and the other peak may be as a result of sharp fall in rainfall. Tanner (1980)[18] suggested that the production of more litter in dry season might be due to water stress. Similar observations had been reported for Nigeria and other tropical forest[10,13]. The lowest litter was recorded in May 2005 in all the age series, S_1 3.51%, S_2 2.60% and S_3 2.63%. The reason for this exceptionally low litter fall in this month was because of intruders on the experimental plots. There was a particular case of disturbance in all the plots across the stands in this month by Buffalo (*Synceruscaffer*). This affected the quantity of litter fall recorded in all the stands. Some of the litter traps were destroyed by the animals which invaded the experimental plots. The animals were being hunted in the adjoining natural forest to the plantation. However, comparison of the mean annual litter fall of this study (Table 2) with some studies in the tropical forest and plantation ecosystem showed that the mean annual litter fall recorded in this study was in agreement with those recorded in other studies.

The differences between this study and some recorded in some tropical forest and plantation ecosystem may be as a result of species and site differences. Site differences according to (Vitousek, 1984)[19] have been observed to affect the total and seasonal fall of litter.

Heavy fall of reproductive structures was observed in February 2006 in all the stands, though there was a marked decrease in S_3. The leaf fall started in November 2005 and reached its peak in February 2006. The total contribution of reproductive parts to the total litter fall in February and March 2006 was particularly high in S_1 and S_2 compared to S_3. In S_1, the percentage contribution of reproductive structures was higher than the leaf, but low fall was recorded in S_3. The reason for this observation may be as a result of the age of the plantation. Other litter (thrash and unidentified litter) had a similar trend in all the stands. A close look at the different fractions showed that "other" had very little contribution to the total litter fall in all the ages. Light penetration in S_1 and S_2 was highly reduced. The main undergrowth under the plantationswere, mostly wildings of *Gmelinaarborea.* However, there were some species identified under the plantation. These include, *Chromolaenaodorata, Elaeisguinensis, Carica papaya, Musa species,Blighiasapida,Mangiferaindica,* and *Sennasiamia.* These species are referred to as invaders which are scattered across the stands.

Pattern of litter fall

The seasonal pattern of litter fall for the period of investigation in the age series is shown in (Figures 1 – 4). Litter fall was continuous throughout the year with the rate being particularly high in September and October 2005, and in February and March 2006 in all the stands. The values for litter fractions other than leaves were very variable and the mean monthly values were not significantly different across the stands. The highest mean monthly values were recorded during February and March in all the stands. This is the first quarter of 2006, when high winds associated with the onset of rainy seasonand with climatic change (no harmattan) in the study area in the month of December 2005. Figures 1 to 4 shows the seasonal patterns of fall of different litter fractions in all the stands. This observation was unusual. The total litter fall (kg/ha) (leaf and reproductive structures) was exceptionally high starting from January 2006 (Table 1).

This trend was noticed in all the stands. The peak of the litter fall in 2005 occurred just after the short "dry spell" in August. This similar trend was observed in all the stands. It also occurred in April 2005 and 2006 respectively. However, whatever reasons that may be responsible for the high litter fall in the peak period, environment factors governing the onset of senescence and the development of abscission process cannot be over looked. Hopkins (1966)[4] summarized the complexity of extrinsic and intrinsic factors which might have influence on leaf abscission under natural conditions and the relationship between them. Statistical analysis showed that, no significant differences at ($P < 0.05$) was found in the pattern or the amount of litter in all the stands. The summary of mean total litter fall (kg/ha) of litter fractions in all the ages is shown in Table 3.

In all the stands, there was a similar trend in total litter fall of different litter components. Twigs, reproductive structures, the unidentified components were negatively correlated as shown in Table 4. However, all litter components were significantly correlated at (< 0.05) on a monthly basis in all the stands.

Table 1
Percentage monthly leaf fall (kg/ha) in *Gmelinaarborea* Plantation at Shasha Forest Reserve

Month/year	S_1 (%)	S_2 (%)	S_3 (%)
April, 2005	4.25	4.19	4.25
May	3.51	2.60	2.63
June	5.12	4.61	5.59
July	6.26	5.60	7.05
August	6.95	6.10	8.09
September	10.11	11.21	13.76
October	18.26	7.23	10.84
November	7.52	8.55	9.31
December	6.13	7.05	7.06
Jan. 2006	4.49	4.34	5.95
Feb	14.43	20.25	9.30
March	9.46	10.38	9.83
April	4.03	7.78	6.33
Total collection	100.6	99.89	99.99

Table 2: Analysis of variance (ANOVA) of litter fractions (oven dry weight) in Kg /ha in 3 stands of *Gmelinaarborea*Shasha Forest Reserve

Parameter		dfMs	F	P- level
Leaves				
Stand (age)	2	340519.2	2.3745	0. 1103 (ns)
Error	30	143408.7		
Twigs				
Stand (age)	2	434.64	0.2225	0.801 (ns)
Error	30	1953.67		
Repr. Parts				
Stand (age)	2	15098.55	0.3377	0.7161 (ns)
Error	30	44705.15		
Other				
Stand (age)	2	2.9365	0.0611	0.9408 (ns)
Error	30	48.0398		

(ns) not significant.

Table 3
Summary of mean annual litter fractions (kg/ha) in *Gmelinaarborea* Plantation age series in Shasha Forest Reserve

Fractions	S_1 (1976)	S_2 (1977)	S_3 (1978)
Lv	761.64	576.10	444.46
Tw	90.02	86.14	91.10
Rs	134.80	156.52	49.65
Others	0.36	0.32	0.29
Mean total	986.82	819.07	586.51

Note. Lv = Leaves Tw = Twig
Rs = Reproductive Structures Others = unidentified litter

Table 4
Correlation relationships of fall of different litter fractions with time

Variable	Month	LV	TW	RS	Others
Month					
LV	.35				
TW	-.06	.35*			
RS	.47*	.24	-.50*		
Others	.66*	.01	-.72*	.70*	1.00

* - were significant at P < 0 .05.

Table 5
Regression summary for dependent variables in the age series (1976, 1977 and 1978 stands)

Stat. Multiple Regress	Regression Summary for Dependent Variable: LOG TOTI R= .44694116, R^2=.19975640, Adjusted R^2=.17812820, F(1,37)=9.2359, p<.00434, Std. Error of estimate: .20188					
N=39	BETA	St. Err. Of BETA	B	SB	t(37)	p-level
Intercept			2.660376	.068576	38.78434	.000000
MONTH	.446941	.147065	.026257	.008640	3.03907	.004338

Table 6
Regression summary for dependent variables in Stand 2

Stat. Multiple Regress	Regression Summary for Dependent Variable: LOG TOT2 R= .64878049, R^2=.42091612, Adjusted R^2=.36827213, F(1,11) = 7.9955, p<.01644, Std. Error of estimate: .17977					
N=13	BETA	St. Err. Of BETA	B	SB	t(37)	p-level
Intercept			2.592872	.105766	24.51527	.000000
MONTH	.648780	.229443	.037679	.013325	2.82764	.016442

Table 7
Summary of mean annual litter fractions (kg/ha) in *Gmelinaarborea* Plantation age series in Shasha Forest Reserve

Fractions	S_1 (1976)	S_2 (1977)	S_3 (1978)
Lv	761.64	576.10	444.46
Tw	90.02	86.14	91.10
Rs	134.80	156.52	49.65
Others	0.36	0.32	0.29
Mean total	986.82	819.07	586.51

Note.
Lv= Leaves
Tw= Twig
Rs= Reproductive Structures
Others= Unidentified litter

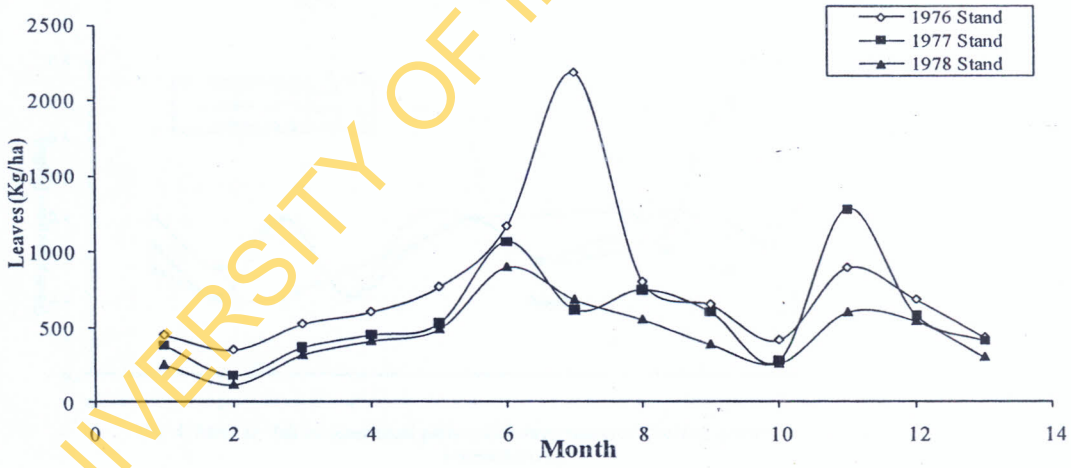

Fig. 1: Monthly fall of leaves under three stands of *Gmelina arborea* in Shasha Forest Reserve.

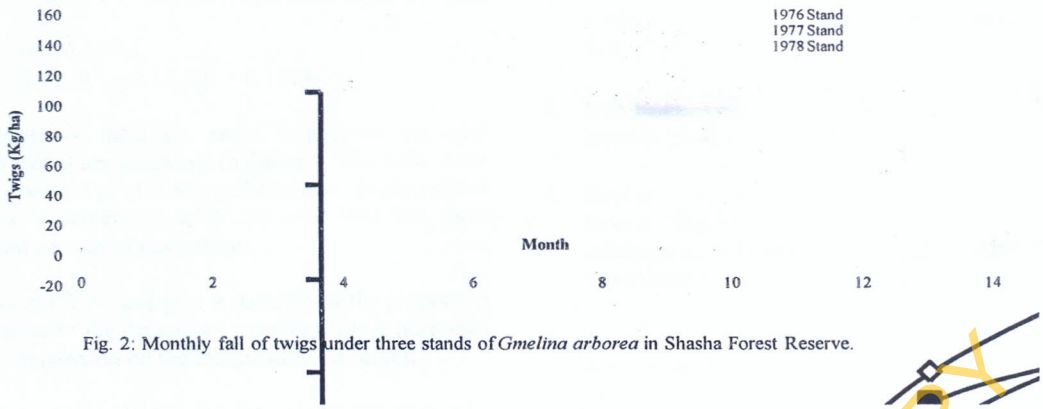

Fig. 2: Monthly fall of twigs under three stands of *Gmelina arborea* in Shasha Forest Reserve.

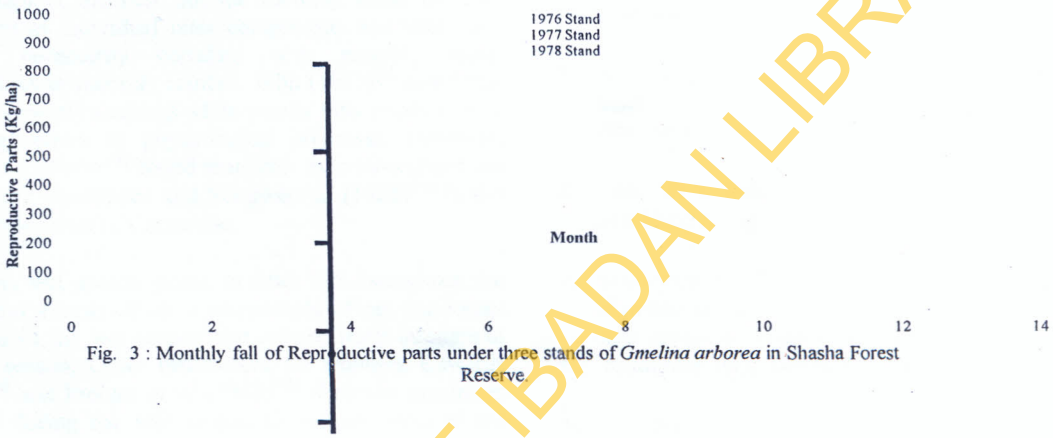

Fig. 3 : Monthly fall of Reproductive parts under three stands of *Gmelina arborea* in Shasha Forest Reserve.

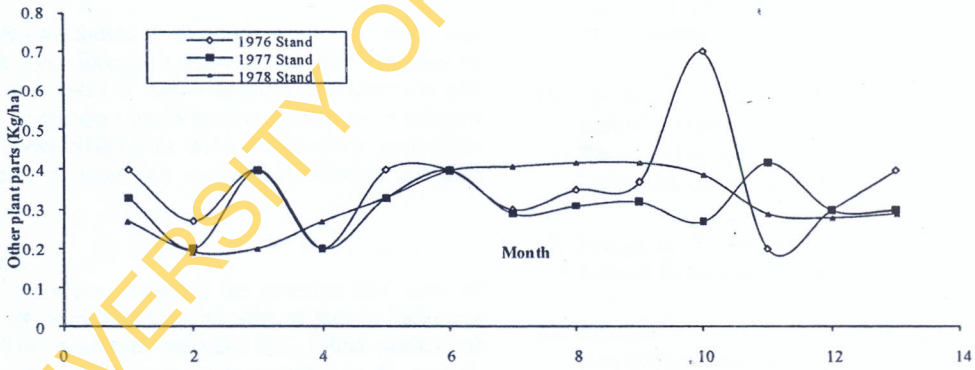

Fig. 4: Monthly fall of other plant parts under three stands of *Gmelina arborea* in Shasha Forest Reserve.

Prediction of litter fall: A number of multiple regressions were carried out using various litter fractions as dependent variables with different combinations of total litter fall, leaf litter, twigs, reproductive structures, others and time in month as independent variables as reported in Table 5. Thus, the regression equation derived for the stands of *Gmelinaarborea* plantation age series is as follows,

Log LF=2.660+0.026M..... (1)
Where $R^2 = 0.20$, $R^2_{adj} = 0.18$, SE = 0.202

The equation for S_2 (i.e the best regression fit) is given as follows,

Log L_2=2.593 + 0.038M.....(2)

Where R^2 = 0.42, R^2_{adj} 0.37, SE = 0.1798.

In this regression analysis, stand two gives the best estimate in this study as shown in Table 6. The table show regression constant as well as coefficients of determination expressed as a percentage of R^2 for total litter fall, litter fractions and periods of assessment.

The percentage R^2 values give a measure of the proportion of the variance of the dependent variables that is attributed to its linear regression on the independent variables.

The pattern and rate of litter fall largely are determined by the species and the climatic regimes in that area. Lam and Dudgeon quoted by Ola – Adams (1987)[20] noted that litter fall throughout the year but the monthly mean rates of production of individual litter components and total litter do not necessarily correlate with monthly mean temperatures or monthly rainfall. John (1973)[2] noted that leaf fall is mainly seasonal while woody litter production is largely governed by physiological processes. However, Nwoboshi (1981b)[21] found that litter falls throughout the year in teak plantations and Songwe*et al* (1988)[10] in the tropical rain forest in Cameroon.

Generally, wet season peaks in litter fall throughout the tropics, but *Acacia albida* is an example of tree that losses its leaves in the wet season and remain leafy throughout the dry season, Other researchers for example Edwards (1977)[22] and Proctor *et al* (1983)[23] observed maximum leaf fall during the wet season in various parts of the tropics.

This has been attributed to the high species diversity that characterize these forests, indicating that litter fall may be spread out as a result of inter - specific differences in leaf shedding time (Rogers andWestman quoted by Nwoboshi (2000)[24]. These differences make it difficult to generalize about patterns of litter fall within and between complex ecosystems.

Conclusion

This study therefore, supports the premise that rates of litter fall vary according to a number of factors including stand age. The mean total recorded inS_1 (older plantation) was higher than the mean total recorded in S_2 and S_3 (younger plantations) respectively.

References

1. Bray J. R. and Gorham, E., Litter production on the forest of the world. *Adv. Ecol. Research* 2, 101 – 157 **(1964)**
2. John D. M., Accumulation and decay of litter and net production of forest in tropical West Africa. *Oikos* **24,** 430 – 435 **(1973)**
3. Nye P. H., Organic matter and nutrient cycles under moist tropical forest Plant and Soil **13,** 33 – 346 **(1961)**
4. Hopkins B., Vegetation of the Olokemeji forest reserve Nigeria. iv. The litter and soil with special reference to their seasonal changes. *J. Ecol.* **54,** 687 – 703 **(1966)**
5. Nwoboshi L. C., Organic matter and nutrient status of some rainforest soils in southern Nigeria. Biotropica **(1978)**
6. Ewel J. J., Litterfall and leaf decomposition in a tropical forest succession in eastern Guatemala. *J. Ecol.* **64,** 293 – 457 **(1976)**
7. Nwoboshi L. C., Nutrient cycling in a managed teak plantation ecosystem. I. Nutrient uptake. *Nig. J. Agric. Science* **3,** 3 – 8 **(1981a)**
8. Lam P.K.S., Dudgeon D., Seasonal effects on Litterfall in a Hong Kong forest. *J. Trop. Ecol.***1,** 55 – 64 **(1985)**
9. Nwoboshi L. C., Biomass and nutrient uptake and distribution in *Gmelinaarborea* pulpwood plantation age series in Nigeria: Journal of *Tropical Forest Resources* **1(1),** 53 – 62 **(1985)**
10. Songwe N. C., F. E. Fasheun, and D. U. U. Okali, itterfall and productivity in a tropical rain forest, Southern Bakundu Forest, Cameroon. *J. Trop. Ecol.* **4,** 25-37 **(1988)**
11. Ojo M.O., Organic matter and nutrient dynamics of the natural rainforest and teak plantation in Akure Forest Reserve, Nigeria. Unpublished Ph.D thesis, Federal University of Technology, Akure. Pp. 126 **(2005)**
12. Madge D. S., Leaf fall and litter disappearance in a tropical forest *Pedobiologia* **5,** 273 – 288 **(1965)**
13. Egunjobi L. C., Litterfall and mineralization in a Teak *(Tectonagrandis L inn. f.)* stands. *Oikos* **25,** 222 – 226 **(1974)**
14. Loria S. A., Litter fall: The most wanted waste. The Ecosystems Research and Development Bureau, Dept. of Environmental and Natural Resources vol. 25, No 3. *J. Canopy* international, philikppiners pp. 12 **(1999)**

15. Soil Management Support Services, (SMSS) Proc. Symp. On Activity Clay (LAC) Soils. Tech **(1986)**

16. Bada S. O., A comparative study of the growth of obeche (*Triplochitonscleroxylon,* K. schum) under plantation and natural forest conditions. M. Phil Thesis, University of Ibadan. 136, **(1977)**

17. Kio P. R. O., Stand development in naturally regenerated forest in South-Western Nigeria. Ph.D Thesis, University of Ibadan, 594 ppKlinge, H. 1977: Preliminary data on nutrient release from decomposing leaf litter in neo tropical rainforest. Amazonia **VI (2),** 193 – 202 **(1980)**

18. Tanner E. V. J., The decomposition of leaf litter in Jamacianmontane rain forest. *J. Ecol.* **69,** 263 – 276 **(1981)**

19. Vitousek P. M., Nutrient cycling and nutrient use efficiency. *American Naturalist* **199,** 553 – 572 **(1984)**

20. Ola-Adams B. A., Effects of spacing on biomass distribution and nutrient content of *Tectonagrandis Linn. f.* Teak and *Terminaliasuperbaengl.Amd Diels (afara).* Ph.D. thesis, Dept of For. Res. Mgt. University of Ibadan, Ibadan **(1993)**

21. Nwoboshi L. C., Litterfall and macro nutrient return to the forest floor. *Nig. J. agr. Sci.***3,** 3-8 **(1981b)**

22. Edwards P.J., Studies of mineral cycling in a montane rain forest in New Guinea II. The Production and disappearance of litter. J. Ecol., **65,** 971 – 992 **(1977)**

23. Proctor J. J., Anderson M., S. C. L. Fodgen S. C. L. andVallack H. W., Ecological studies in four contrasting lowland rain forests in Gunung Mulu National Park, Sarawak. 11. Litterfall, litter standing crop and preliminary observations on herbivory. *J. Ecol.* **71,** 261-283 **(1983)**

24. Nwobosh L. C., The nutrient factor in sustainable forestry. Ibadan University press. Pp 254 **(2000)**

25. Monogr. No. 14 Soil Manage. Support Serv., USDA, Washington, DC. USA. **(1986)**

26. Songwe N. C., Litter production and decomposition in a tropical rainforest, Southern Bankundu Forest Reserve, Cameroon, Ph.D. Thesis University of Ibadan. Nigeria. Pp. 209 **(1984)**