Ethiopian Journal of Environmental Studies & Management 12(5): 539 – 550, 2019.
ISSN:1998-0507 doi: https://ejesm.org/doi/v12i5.6
Submitted: July 23, 2019 Accepted:October 21, 2019

SOIL SEED BANK DIVERSITY IN SELECTED SACRED GROVES OF TROPICAL RAIN FOREST OF SOUTHWESTERN, NIGERIA

***OYELOWO, O.J.,[1] AGBOOLA, D.A.,[2] AKINYEMI, O.D.,[1] OLATIDOYE, O.R.[1]**
[1]Department of Forest Conservation and Protection, Forestry Research Institute of Nigeria, Ibadan
[2]Department of Pure and Applied Botany, Federal University of Agriculture, Abeokuta
*Corresponding author: tayooyelowo@yahoo.com

Abstract
Soil seed banks play an important role in tropical rainforest regeneration. Regeneration potentials of 5 sacred groves (Igbo-Ile, Igbo-Oba, Igbo-Olua, Igbo Olodumare, Igbo-Gbopo) in the three states of southwestern Nigeria were purposively selected and assessed. On each site, a representative 50m x 50m plot labeled with pegs, where viable seeds bank was sampled. On each plot, ten randomly located subplots of 1m x 1m were sampled using a soil auger. Then the samples were kept inside screen house and watered regularly. The result revealed a total of 1,870 seedlings found in the five sacred groves. The highest number of germinated seeds was found in Igbo-Olodumare (538 seedlings), followed by Igbo-Gbopo (416 seedlings), Igbo-Oba (340 seedlings), Igbo-Olua (331 seedlings) and the least in Igbo-Ile (245 seedlings). Shannon diversity Index ranged from 2.203 to 2.526 with high diversity index recorded in Igbo-Olodumare (2.526). A total of 21 families (42 plant species) were found in the study areas. Cucurbitaceae was found to be dominant family and Chromolaena odorata had the highest frequency of 310. Simpson Similarity between the sacred groves varied from 0.872 to 0.997. High similarity value was recorded between Igbo-Ile and Igbo-Gbopo (0.997), while low similarity was found between Igbo-Oba and Igbo-Olodumare (0.872). Dialium guineense and Spondias mombin were tree species encountered in all the sacred groves. The regeneration potentials of these sacred groves was generally poor. Comparison of the soil seed bank in other sacred groves would be useful in suggesting restoration measures for the sacred groves.

Key Words: *Seed bank, Soil, Scared grove, regeneration, Igbo-Ile, Igbo-Oba, Igbo-Olua, Igbo Olodumare, Igbo-Gbopo*

Introduction

Nigeria's tropical rainforests occupy approximately 9.7 percent of the country's complete land mass of 983.21 km2 and are the main source of bulk timber in Nigeria (Jonathan *et al*., 2009). The sacred groves of southwest Nigeria are the relics of once extensive tropical rainforest of Nigeria. The groves occur as isolated patches that have been protected and conserved by either indigenous knowledge, taboos or on religious grounds (Oyelowo, 2014). These groves can be seen as a distinctive instance of our ancestors ' ecological knowledge and sustainable natural resource management (Rajendraprasad, 1995).

Soil seed banks play a key role in tropical rainforest regeneration (Hopkins and Graham, 1983). As they contribute considerably to ecological processes, soil seed banks are regarded as vital constituents of plant communities, according to Harper (1993). Seed banks in successive forests tend to be bigger (Saulei and Swaine, 1988) and consist primarily of pioneer plants (Nepstad *et al*., 1996), but seed banks that reflect human dominated disturbance regimes are probable to contain species that have developed under comparable natural disturbance regimes or originated elsewhere in comparable human-dominated landscapes (Pickett and McDonnell, 1989). These seeds may stay in the soil for a longer period and form a persistent seed bank where as seeds of most of the climax forest species form a transient seed bank (Whitmore, 1983).

In comparison, Chandrashekara *et al*. (1993) showed that the density of germinable plants in a wet forest seed bank of western Kerala Ghats, India, fluctuates significantly with the moment of year, and the plant density was high during the monsoon season. In some secondary successions in the tropics, buried seed banks seem to be a significant source of plant colonists (Kellman, 1970). As illustrated by seed longevity in experimental studies (Hopkins and Graham 1987), they are considered ' persistent ' (Grime, 1979). Swaine and Hall (1983) indicated that the forest composition following a disturbance could be predicted from the understanding of the soil seed bank prior to the disturbance, although the significance of plants in dry forest regeneration is significantly influenced by the environmental conditions for germination. Seed viability and dormancy are genetically regulated characters while humid environments may break the dormancy of seeds (Vázquez- Yanes and Orozco-Segovia, 1990).

As they contribute considerably to ecological processes, seed banks are regarded vital components of plant communities. Following disruption, the recoverability of vegetation is thought to lie primarily in the buried plant population (Uhl *et al*., 1981). The understanding of the dynamics and function of seed banks has become a great challenge to plant community ecologists, as this understanding is necessary to enable determining the role of this community trait in ecosystem functioning and also to improve integrated management of ecosystems. Although a complete set of topics have been described on seed banks such as the spatial distribution of seeds in soil (Lavorel *et al*., 1991), the persistence of seed in soil (Hendry *et al*., 1995), the effects of environmental factors on the dynamics of seed banks (Kitajima and Tilman, 1996), and the similarity of the composition of seed species in the aboveground vegetation (Lavorel *et al*., 1991). Much has not been undertaken on the regeneration of sacred groves in Nigeria. Hence, the article studies the diversity of soil seed bank in regeneration of selected sacred groves in southwest Nigeria.

Study Area

Southwest Nigeria's tropical rainforest ecological area is a constant belt around the globe between Latitude 24° S and 24° N and Longitude 10° E and 20° W (Fig. 1) and 300km wide in its widest area (Okojie, 1994). The dry and rainy seasons are distinct, with an average annual rainfall and temperature of 1489 mm and 26.5° C respectively. A large proportion of plant species belong to the tropical rainforest area. The FEPA (1992) domestic study reported 5,018 species of plants in the lowland rainforest ecosystem in Nigeria, 205 of which are endemic. The reason for its richness is due to the favourable climatic conditions existing and availability of fertile soil. All soils undergo gradual development from the parent materials but their characteristic change as they mature. These soils vary in physical and chemical properties but they exhibit some common characteristics, most of them are well – drained by several rivers, bright red or brown in colours and dominated by the kaoline type of clay. Their humus content tends to be low and is mostly confined to the uppermost horizons. Soils are predominantly ferruginous tropical, typical of the type found in the rainforest area of southwestern Nigeria in intensely weathered fields of basement complicated structures (Onyekwelu *et al*., 2008). 5 sacred groves (Igbo-Ile, Igbo-Oba, Igbo-Olua, Igbo Olodumare, Igbo-Gbopo) in the three states of southwestern Nigeria were purposively selected and assessed (Table 1).

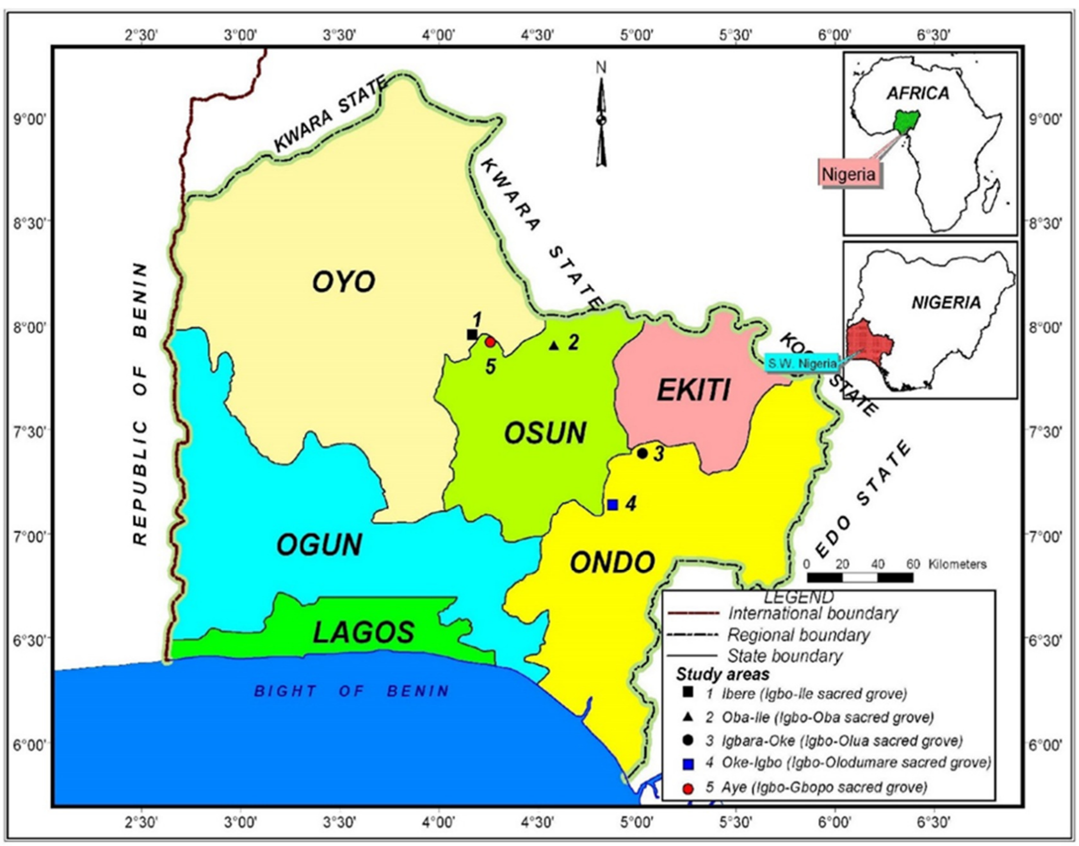

Fig. 1: Map of South-western states, Nigeria, showing the location of the sacred groves with maps of Africa and Nigeria in inset.

Table 1: Sacred Groves and Their Location

Sacred Groves	Town	Local Government Area	State
Igbo-Ile	Ibere	Ogo Oluwa	Oyo
Igbo-Oba	Oba Ile	Olorunda	Osun
Igbo-Olua	Igbare Oke	Ifedore	Ondo
Igbo-Olodumare	Oke Igbo	Oke Igbo	Ondo
Igbo-Gbopo	Aye	Ejigbo	Osun

Materials and Methods

Sampling Procedure and Laboratory Processes

Regeneration Potentials was assessed. On each site, a representative 50m x 50m plot was marked out with pegs. Viable seeds bank and vegetation were sampled within these plots. On each plot, ten randomly located subplots of 1m x 1m were sampled using a soil auger. In each subplot, after removal of the litter layer, ten auger points were extracted on a regular grid (one central row of four cores and two outer rows of three cores each). Ten cores from each depth were pooled per lot, based on Thompson (1993) key of seed classification, which uses the distribution of seeds for the determination of the persistence types. The pooled soil samples were focused using the technique of bulk reduction for short-term seed bank research, as this technique encourages fast and complete seed germination of many species (ter Heerdt *et al.*, 1996). The soil has been sieved by two 2.0 mm sieves. By doing so, the samples eliminated rhizomes and roots, and the coarse and very fine soil removed from the particles resulted in a significant reduction in bulk. The samples in each were spread into 5 mm thick layers in distinct trays and put outdoors, enabling natural daily changes in temperature to support germination (Thompson and Grime, 1983; Poschlod, 1991). Then the samples were held inside the screen house, allowing free exchange of gas and moisture, but avoiding contamination of weed-borne plants.

The trays were frequently washed and weekly checked for seedlings. Seedlings were recognized and extracted using Muller's main (1978). Unidentified seedlings were transplanted into a polythene plot and grown until it was feasible to identify them. The experiment was concluded after 15 weeks. Although some viable seeds may have remained in the soil samples beyond the experiment, for reasons discussed by ter Heerdt et al. (1996), the application of the concentration method should have resulted in the complete germination of seeds of most species within the first 6 weeks.

Technique for Data Analysis

Diversity index and tree species classification

All encountered plant species have been categorized into families. Their occurrence of species was acquired to ascertain species abundance and evenness. The following indices of biodiversity were used to achieve diversity and evenness variety, uniformity within each sacred grove.

Species diversity index: Species diversity is a measure of heterogeneity of a site taking into consideration the number and the density of individual species. Each sacred grove was assessed using the Simpson (1949).

$$\frac{\Sigma\{ni(ni-1)\}}{N(N-1)}$$

where, I = Simpson's diversity index; ni = Number of individuals of ith species enumerated;
N = Total number of species enumerated
Species evenness (E) in each plot will be calculated by adopting Shannon's equitability (EH) as stated by Kent and Coker (1992):

$$EH = \frac{\Sigma \text{Piln (Pi)}}{Ln(s)P}$$

where, S = the total number of species in the habitat; P1 = proportion S (species in the family) made up of the ith species; ln = natural logarithm.
Sorensen's species similarity index (SI) following Nath *et al*. (2005) between any two sites will be calculated using:

$$SI = \left(\frac{2c}{a} + b\right) X\ 100$$

where, C = number of species in sites a and b; a, b = number of species at sites a and b

Result

Soil Seed Bank

Table 2 revealed a total of 1,870 seedlings found in the sample quadrants in the five sacred groves. The highest number of germinated seeds was found in Igbo-Olodumare (538 seedlings), followed by Igbo-Gbopo (416 seedlings), Igbo-Oba (340 seedlings), Igbo-Olua (331 seedlings) and the least in Igbo-Ile (245 seedlings). Shannon diversity Index ranged from 2.203 to 2.526. High diversity index was recorded in Igbo-Olodumare (2.526), followed Igbo-Gbopo (2.505), Igbo-Oba (2.263), Igbo-Ile (2.22), while Igbo-Olua had the lowest diversity index (2.203). The species evenness ranged from 0.6965 and 0.8404. Igbo Ile had the highest evenness (0.8404), followed by Igbo-Olodumare (0.8338), Igbo-Gbopo (0.816), Igbo-Oba (0.8013) and the least was Igbo-Olua (0.6965).

A total of 21 families were found in the study areas. Asteraceae was found to be dominant family having *Chromolaena odorata, Tridax procumbens, Ageratum conyzoides, Bidens pilosa, Synedrella nodiflora* followed by Acanthaceae, Cyperaceae, Poaceae, and Rubiaceae (4 species each). Among the families with only 2 species are Caesalpinioideae, Convolvulaceae, Dioscoreaceae, Fabaceae etc. Basellaceae, Lamiaceae, Portulaceae, Smilacaceae had only 1 species (Fig. 2). In all the sacred groves, *Chromolaena odorata* had the highest frequency of 310, followed by *Tridax procumbers* (120), *Acanthus montanus* (118), and *Momordica charantia* (110). Among the species of low frequency are: *Acalypha fimbriata* (5), *Dialium guineese* (6), *Eragrostis tremula* (6) and *Agerathum conyzoides* (7) (Table 3). The seed emergence composition in Igbo-Ile S.G. showed that *Chromolaena odorata* had the highest frequency (53), followed by *Centrosema pubescens* (40). The least species encountered was *Dioscorea species* (5). Also in Igbo-Oba sacred grove, *Chromolaena odorata* had the highest frequency (71), followed by *Basella alba* (68), *Lapartea aestuans* (33), *Oldenlandia herbacea* (32), *Andropogon tectorum* (31), while *Eragrostis tremula* (6) was recorded as the least in the sacred grove. *Chromolaena odorata* was also recorded to have the highest frequency of 68 in Igbo-Olua sacred grove, followed by *Tridax procumbens* (57), *Chamaecrista mimosoides* (42), *Euphorbia heterophylla* (34) *and Ipomoea tribola* (32). *Mitracarpus villosus* and *Oldenlandia herbacea* (3). However, *Momordica charantia* had the highest frequency (71) in Igbo-Olodumare sacred grove, followed by *Acanthus montanus* (65), *Chromolaena odorata* (64), *Mucuna pruriens* (59), *and Asystasia pelicida* (34). The least species recorded in the sacred grove was *Dioscorea species* (4). *Tridax procumbens* was recorded to be the highest frequency (63) in Igbo-Gbopo, followed by *Chromolaena odorata* (54), *Ludwigia decurrens* (51), *Talinum fruticosum* (43), *and Bidens pilosa* (33). The least species recorded was *Luffa cylindrica* (6).

Similarity Indices of Seed Bank Species among the Sacred Groves

Table 4 showed the similarity indices among the sacred groves. Simpson Similarity between the sacred groves varied from 0.872 to 0.997. High similarity value was recorded between Igbo-Ile and Igbo-Gbopo (0.997), followed by Igbo-Olodumare and Igbo-Gbopo (0.995), Igbo-Ile and Igbo-Olua (0.991). However, low similarity was found in Igbo-Oba and Igbo-Olodumare (0.872), Igbo-Olua and Igbo-Olodumare (0.887).

Table 2: Summary of Diversity Indices of Seedling Emergence in the Sacred Groves

Sacred Grove	Igbo Ile	Igbo Oba	Igbo Olua	Igbo Olodumare	Igbo Gbopo
No of seedlings/Plot	245	340	331	538	416
No of Species	11	12	13	15	15
No of family	7	9	8	12	8
Diversity index	2.224	2.263	2.203	2.526	2.505
Species evenness	0.8404	0.8013	0.6965	0.8338	0.816

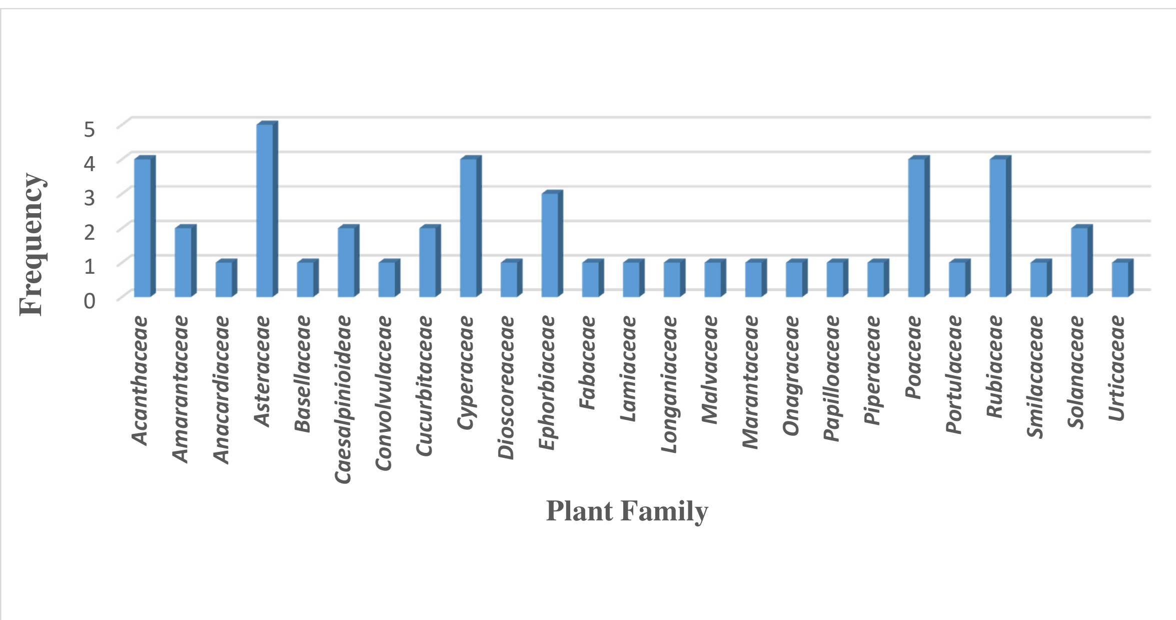

Fig. 2: Family Composition in the selected sacred groves

Table 3: Density of Seedling that Emerged in the Five Sacred Groves

	Sacred groves				
Species	Igbo Ile	Igbo Oba	Igbo Olua	Igbo Olodumare	Igbo Gbopo
Acalypha fimbriata	0	0	5	0	0
Acanthus montanus	22	0	0	65	31
Achyranthes aspera	0	0	0	0	18
Ageratum conyzoides	0	0	0	0	7
Andropogon tectorum	0	31	0	0	0
Asystasia gangetica	9	0	0	24	18
Asystasia pelicida	15	0	0	34	0
Axonopus compressus	0	13	0	0	0
Basella alba	0	68	0	0	0
Bidens pilosa	0	0	0	0	33
Capsicum frutescens	0	0	0	0	8
Centrosema pubescens	40	0	0	15	0
Chamaecrista mimosoides	0	0	42	0	0
Chromolaena odorata	53	71	68	64	54
Dialium guineense	0	0	6	0	0
Digitaria ternata	19	0	0	5	0
Diocorea species	5	0	0	4	0
Eragrostis tremula	0	6	0	0	0
Euphorbia heterophylla	0	0	34	0	0
Ipomoea tribola	0	0	32	0	32
Justicia flava	13	0	0	0	22
Lapartea aestuans	0	33	0	0	0
Ludwigia decurrens	0	0	0	0	51
Luffa cylindrica	0	0	6	0	6
Mariscus alternifolius	32	0	0	33	0
Mitracarpus villosus	0	23	3	0	0
Momordica charantia	0	0	28	71	11
Mucuna pruriens	0	0	0	59	0
Oldenlandia herbacea	0	32	3	0	0
Oplismenus burmannii	0	0	0	23	0
Peperomia pellucida	0	15	37	0	0
Phyllanthus amarus	21	0	0	25	0
Physalis angulata	0	16	0	0	0
Platostoma africanum	0	0	10	0	0
Sida acuta	16	0	0	38	0
Smilax anceps	0	0	0	44	0
Spigelia anthelmia	0	0	0	34	0
Spondias mombin	0	15	0	0	0
Synedrella nodiflora	0	0	0	0	19
Talinum fruticosum	0	0	0	0	43
Thaumatococcus daniellii	0	17	0	0	0
Tridax procumbens	0	0	57	0	63
Total	245	340	331	538	416

Table 4: Similarity Indices of Seed Bank Species among the Sacred Groves

	Igbo Ile	Igbo Oba	Igbo Olua	Igbo Olodumare	Igbo Gbopo
Igbo Ile	1				
Igbo Oba	0.987	1			
Igbo-Olua	0.991	0.947	1		
Igbo Olodumare	0.896	0.872	0.887	1	
Igbo Gbopo	0.997	0.903	0.917	0.995	1

Discussion

Seed bank qualities of a specific habitat can help manage the current vegetation's composition and structure, and to restore indigenous vegetation in several forms (Hui and Keqin, 2006). The total density of 1,870 seedlings found in the five sacred groves was low compared to a total of 7,857 seedlings (49 species) recorded in a study in a regenerating Tropical rainforest by Oladoye *et al.* (2016). The low emergence of seedlings across all the sacred groves could be attributed to the human activities threatening the existence of sacred groves. Others could be non-existence of gaps in the forest canopy within the sacred groves leading to dormancy of the forest tree seeds to quickly emerge. Grasses and herbs dominated the density of plants recorded. This observation could be attributed to early successional and light–demanding species. The permanent forest soil banks comprise predominantly early-successive and light-demanding species seeds (Matin *et al.*, 2007). Another observation could be due to the presence of agricultural land, secondary forest around the sacred groves. According to Grandin (2001), seeds are spread from neighboring populations in different ways, which subsequently play little or no role after a disturbance in regenerating the mature vegetation. Some researchers have reported the dominance of herbaceous species in the forest soil seed bank as recorded in this research (Cao *et al.*, 1997, Oke *et al.*, 2006). The research showed that the re-growth of the sacred tree species depends entirely on the existence of mature forest vegetation and is not dependent on the soil seed bank for regeneration following disturbances. According to Zaghloul (2008), diversity is a measure of community structure that can be described as the amount of distinct species occurring in an area or sample, the number of individual organisms present, and the distribution of these organisms among the various species. Shannon diversity Index ranged from 2.203 to 2.526. High diversity index was recorded in Igbo-Olodumare (2.526), followed Igbo-Gbopo (2.505), Igbo-Oba (2.263), Igbo-Ile (2.22), while Igbo-Olua had the lowest diversity index (2.203).

A total of 21 families were found in the study areas. Cucurbitaceae was found to be dominant family having 5 species, followed by Cyperaceae, Ephorbiaceae, Poaceae, and Rubiaceae (4 species each). Gomaa (2012) reported the same 21 family of Asteraceae (12 species), Fabaceae (9 species), Poaceae and Brassicaceae (eight species each). The most dominance species in these seed banks was *Chromolaena odorata* (310), followed by *Tridax procumbens* (120), *Acanthus montanus* (118) and *Basella alba* (68). The dominance of *Chromolaena odorata* could be attributed to the invasive nature of the weed. Perera

(2005) has reported *C. odorata* as the most prevalent species of herbaceous dicot. *C. odorata* has been reported by Perera (2005) as the most common herbaceous dicot species. *Cederela odorata* is regarded the most problematic invasive species in protected rainforests in Africa as an invasive weed of field plants in its introduced range (Struhsaker *et al.,* 2005*)*. Witkowski (2002) says *C. Odorata* is considered a nutrient demanding early succession species. It benefits from the soil flush that becomes accessible after disturbance. It has a poor association with the canopy cover and on the edge of forest fields appears to be most abundant (Feleke, 2003).

Due to low seed production or absence of apparent (or no) dormancy mechanism in most woody species, the existence of few woody species in seed banks may appear. *Dialium guineense and Spondias mombin* only were tree species encountered in all the sacred groves. Oke *et al.* (2006) recorded that a total of 41 species, composed of 5 woody species and 36 herbaceous species, dominated the seed bank in all six. The lack of seedling with large seedlings in the seed bank could be due to the concept that big seeds are transient in the seed bank as they do not have lengthy dormancy periods (Swaine, 2001, Martins and Engel, 2007) and as a result their amount in the soil plant community is decreased (Dalling and Hubbell, 2002). Schupp *et al*. (1989) noted that the excessive predation danger facing them in a maturing forest is another potential factor influencing the low representation of big seedling species. The scanty tree seeds (2 species) contained in the sub-surface soil indicates the weak potential contribution of the forest regeneration sub-surface soil seed banks. It could also be due to seeds that have already accumulated in the soil that have lost their viability after a long time leading to a reduction in the seed density of the soil.

Conclusion

These sacred groves regeneration potential was relatively poor. It would be helpful to compare the soil seed bank in other sacred groves to suggest restoration measures for the sacred groves. To assess and validate these findings, it is essential to conduct other research at distinct locations.

References

Chandrashekara, U.M. and Ramakrishnan, P.S. (1993). Germinable soil seed bank dynamics during the gap phase of a humid tropical forest in the western ghats of Kerala, India. *Journal of Tropical Ecology,* 9: 455-467.

Dalling, J.W. and Hubbell, S.P. (2002). Seed size, growth rate and gap microsite conditions as determinants of recruitment success for pioneer species. *Journal of Ecology,* 90: 557–568.

Dudley, N. and Stolton, S. (1999). Threats to forest protected areas. A research report from the IUCN and the World Bank/WWF Alliance for Forest Conservation and sustainable Use. IUCN.

Feleke, A.K. (2003). Land use and land cover in relation to *Chromolaena odorata* distribution: mapping and change detection in St. Lucia wetland area, South Africa. Enschede, ITC.

Gomaa, N.H. (2012). Soil seed bank in different habitats of the Eastern Desert of Egypt*. Saudi Journal of*

Biological Sciences. Volume 19, Issue 2

Grandin, U. (2001). Short-term and long-term variation in seed bank/vegetation relations along an environmental and successional gradient. *Ecography*, 24: 731–741.

Grime, J.P. (1979). *Plant Strategies and Vegetation Process*. Wiley, New York.

Hall, J.B. and M.D. Swaine. (1980). Seed stocks in Ghanaian forest soils. *Biotropica,* 12: 256-263.

Harper, J.L. (1983). Population Biology of Plants. Academic Press, London. pp 892.

Hendry, G.A.F., Thompson, K. and Band, S.R. (1995). Seed survival and persistence on a calcareous land surface after a 32-year burial. *J. Veg. Sci. 6,* 153–156.

Hopkins, M.S. and Graham, A.W. (1987).The species composition of soil seed banks beneath lowland tropical rain forests in north Queensland, Australia. *Biotropica* 15: 90-99.

Hui L, Keqin W (2006). Soil seed bank and aboveground vegetation within hillslope vegetation restoration sites in Jinshajing hot-dry river valley. *Acta Ecologica Sinica,* 26(8): 2432-2442.

Jonathan, C.O., Mosandi, R. and Stinnim, B. (2007). Tree species diversity and soil status of two natural forest ecosystems in low land humid tropical rainforest region of Nigeria. Proceedings of a Conference on International Agricultural Research for Development. October 9-11, 2007. University of Kassel-Wltzenhausen and University of Gottingen

Kellman, M.C. (1970). *Secondary Plant Succession in Tropical Montane Mindanao*. Research School of Pacific Studies, Australian National University, Canberra. No. BG/2, Australia.

Kent, M. and Coker, P. (1992). Vegetation description and analysis a practical approach, Bulhaven press London 363pp.

Kitajima, K. and Tilman, D. (1996). Seed banks and seedling establishment on an experimental productivity gradient. *Oikos,* 76: 381–391.

Lavorel, S., Lebreton, J.D., Debussche, M. and Lepart, J. (1991). Nested spatial patterns in seed bank and vegetation of Mediterranean old-fields. *J. Veg. Sci*. 2: 367–376.

Lieberman, D. (1979). Dynamics of Forests and Thicket on the Acer Plains, Ghana. Ph.D. Thesis, University of Ghana, Legon, Ghana.

Martin, Z., Rein, K., Kersti, P., Elle, R. and Mari, M. (2007). Soil Seed bank and vegetation in mixed coniferous forest stands with different disturbance regions. *Forest Ecology and Management,* 250: 71 – 76.

Martins, A.M. and Engel, V.L (2007). Soil seed banks in tropical forest fragments with different disturbance histories in southeastern Brazil. *Ecological Engineering,* 31: 165–174.

Muller, F.M. (1978). Seedlings of the north-western European lowland: A flora of seedlings. Junk Publ., The Hague.

Nath, P.C., Arunchalam, A., Khan, M.L., Arunchalam, K. and Bharbhuiya, A.R. (2005). Vegetation analysis and tree population structure of tropical wet evergreen forests in and around Namdapha National Park, Northeast India. *Biodivers Conserv* 14:2109–2136

Nepstad, D., C. Uhl, C.A. Pereira & J.M.C. da Silva. (1996). A comparative study of tree establishment in abandoned pasture and mature forest of eastern Amazonia. *Oikos* 76: 25-39.

Oke, S.O., Oladipo, O.T. and Ishichei, A.O. (2006). Seed bank dynamics and regeneration in a secondary lowland rainforest in Nigeria. *International Journal of Botany* 2 (4): 363-37.

Okojie, J.A. (1994). Role of the Forestry sub-sector in the Nigerian Economy. Paper presented at the workshop on Forest Policies and Values. Agricultural and Rural Management Training Institute (ARMTI). Ilorin, Kwara State, Nigeria. 4pp.

Oladoye A.O., Aduradola A.M. and Oyelowo O.J. (2016). Assessment of Seed Bank Dynamics in a Regenerating Tropical Rainforest Ecosystem in South-Western Nigeria. *Nigerian J. Ecology* 15(1): 47-57.

Onaindia, M. and Amezaga, I., (2000). Seasonal variation in the seed banks of native woodland and coniferous plantations in Northern Spain. *For. Ecol. Manage*. 126: 163–172.

Onyekwelu, J.C., Adekunle, A.J. and Adeduntan, S.A. (2005). Does tropical rainforest ecosystem possess the ability to recover from severe degradation? In: Popoola L, Mfon P, Oni PI (eds) Sustainable forest management in Nigeria: lessons and prospects. Proceeding of the 30th Annual Conference of the Forestry Association of Nigeria, Kaduna, 07th–11th Nov. 2005, pp 145–163.

Oyelowo O.J. (2014). Floristic composition, soil nutrients status and regeneration potentials of selected sacred groves in rainforest zone of south-west Nigeria. Federal University of Agriculture, Abeokuta. Unpublished Ph.D. Thesis.

Perera, G.A.D. (2005). Diversity and dynamics of the Soil Seed bank in tropical deciduous forests of Sri Lanka *Tropical Ecology,* 46(1): 65 – 78.

Pickett, S.T.A. and McDonnell, M.J. (1989). Changing perspectives in community dynamics: a theory of successional forces. *Trends in Ecology and Evolution,* 4: 241-245.

Poschlod, P. (1991). Diasporenbanken in Boden – Grund-lagen and Bedeutung. In: Schmid, B. and Stocking, J. (eds), *Populationsbiologie der Pflanzen*: 15-35. Birkhauser, Basel.

Rajendraprasad, M. (1995). The Floristic, Structural and Functional Analysis of Sacred Groves of Kerala. Ph.D. thesis, Kerala University, Thiruvananthapuram. 242 pp.

Saulei, S.M. and Swaine, M.D. (1988). Rain forest seed dynamics during succession at Gogol, Papua New Guinea. *Journal of Ecology* 76: 1133-1152.

Schupp, E. W., H. F. Howe, C. K. Augspurger, and D. J. Levey. (1989). Arrival and survival in tropical treefall gaps. *Ecology,* 70: 562–564.

Simpson E.H. (1949). Measurement of Diversity Nature London.

Strutisaker, P.J., Strisaker, T.T., Siex, K.S. (2005). Conserving Africa's rainforests: Problems in Protected areas and possible Solutions.

Biological Conservation, 123(1): 45 – 54.

Swaine, M.D. and Hall, J.B. (1983). Early succession on cleared forest land in Ghana. *Journal of Ecology,* 71: 601-627.

Swaine, M. (2001). Protocol for assay of soil seed banks. In: Proceedings of the Euroworkshop on Functional Groups in Tropical Forest Trees. Available at http://www.nbu.ac.uk/tropical/SSB protocol_Swaine.doc (accessed April 10, 2008).

ter Heerdt, G.J.N., Verweij, G.L. and Bakker, R.M. (1996). An improved method of seed-bank analysis: seedling emergence after removing the soil by sieving.-*Funct. Ecol*. 10:144-151.

Thompson K. and Grime, J.P. (1983). A comparative study of germination responses to diurnally-fluctuating temperatures. *J. Appl. Eco*. 20: 141-156

Uhl, C., Clark, K., Clark, H. and Murphy, P. (1981). Early plant succession after cutting and burning in the Upper Rio Negro region of the Amazon Basin. *J. Ecol*. 69: 631–649.

Vázquez-Yanes, C. and Orozco-Segovia, A. (1990). Seed dormancy in the tropical rain forest. pp. 247-259. *In*: K.S. Bawa & M. Hadley (eds.) *Reproductive Ecology of Tropical Forest Plants*. UNESCO/Parthenon, Paris and Carnforth.

Whitmore, T.C. (1983). Secondary succession from seed in tropical rain forests. *Forestry Abstract,* 44: 767-779.

Zaghloul, M.S. (2008). Diversity in soil seed bank of Sinai and implications for conservation and restoration. *African Journal of Environmental Science and Technology,* 2(7): 172-184.