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COMPARATIVE STUDY OF SOIL SEED STOCK AT *Hevea brasiliensis* PLANTATION AND SWAMPY SOIL OF RIVER ANYA AT UMUDIKE, NIGERIA

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ABSTRACT

Seeds stocked in swampy soil and *Hevea brasiliensis* plantation soil at Umudike were assessed by enumerating the seeds that germinated from soil monoliths collected from the sites at different months. On the 15 day of each month, four soil monoliths, each 50 x 25 x 10 cm were taken from the swampy soil of which two soil monoliths were taken from the depth 0 -10 cm and the remaining two from 10 - 20 cm depth. The same method was used in collecting four soil monoliths from *Hevea brasiliensis* plantation from November, 2007 to February, 2008. The effect of light and depth were investigated on the seeds stocked in the soil for 16 weeks. From soil monoliths collected from the swampy soil, a total of 18 species comprising 2489 (97%) individuals germinated from soil monoliths taken from 0-10cm depth and kept in open. Whereas a total of 14 species comprising 116 (3%) individual seeds germinated from soil monoliths taken from *Hevea brasiliensis* plantation at the same depth. From 10-20 cm depth in open, a total of 12 species comprising 928 (98%) individual seeds germinated from the soil monoliths collected from swampy soil while 10 species comprising 20 (2%) individual seeds germinated from soil monoliths collected from *Hevea brasiliensis* plantation. Depth has significant effect ($p < 0.05$) on the number of seeds germinated from the soil monoliths in the shade, a total of seven species comprising 151 (77%) individual seeds germinated from swampy soil while nine species comprising 45 (23%) individual seeds germinated from *Hevea brasiliensis* from the 0-10 cm. From 10-20 cm depth, six species comprising 113 (88%) individual seeds germinated from swampy soil while four species comprising 15 (12%) individuals germinated from *Hevea brasiliensis* plantation. Seed germination started within the first seven days of collection and germination stopped after seventy days. There is significant difference ($p < 0.05$) between the number of seeds germinated at the swampy soil and the number germinated per month from the soil monoliths collected from the *Hevea brasiliensis* plantation. The more number of seeds germination from soil depth in the open is due to unfiltered red wavelength radiation that reached the soil monolith. The more number of seeds germination from the swampy soil is due to annual seed production of the grasses, sedges and ferns. Neither pioneer nor climax tree species seeds germinated from the swampy soil but four pioneer species seeds *Harungana madagascariensis*; *Macaranga barteri*; *Uvarea chamae* and *Hevea brasiliensis* germinated from the soil monoliths collected from the *Hevea brasiliensis* plantation. It is recommended that climax economic tree species such as *Khaya ivorensis* and *Entandrophragma spp* should be introduced, as they were absent both in the swampy soil and *Hevea brasiliensis* plantation. It is recommended that germination of seeds and planting of desirable emergent tree seedlings/stumps should be done by trained foresters to achieve the functions of the forest especially in carbon sink and climate change.

Keywords: seeds, *Hevea brasiliensis*, swampy soil, monoliths, plantation, trees, climbers, river Anya.

INTRODUCTION

The tropical rainforest of Nigeria occurs at the southern part of the country. The rainforest is faced with the problems of deforestation and man understanding fully how the forest regenerated itself with desirable plant species. Several silvicultural experiments such as the Group Method; the Tropical Shelter-wood System (Kennedy, 1935; Lowe 1975) aimed at understanding the process of regenerating the rainforest failed to achieve their major objectives. Some writers such as Jones (1956) had wanted to know if the rainforest could reproduce a forest as the one that existed then. Plantations of exotic and indigenous tree species such as *Gmelina arborea*, *Tectona grandis*, *Cedrela odorata* and *Triplochiton scleroxylon* were tried but the money involved in their establishment was enormous. Some writer had inquired whether the Tropical rainforest could survive (Spears, 1979). Okali, (1979) recorded that the rainforest of Nigeria was disappearing at an estimated rate of over 250 square kilometers a year and the rainforest could be wiped out before 2020. Several serious efforts aimed at maintaining the rainforest such as tree planting operations were tried. These efforts also failed because, the organizers of the operations thought that forestry is a Chinese nut. In their operations, tree seeds were collected and germinated and the resultant seedlings planted anyhow by anybody and at anytime resulting in both massive death of planted seedlings and the production of diseased trees. With the disappearance of the rainforest, the timber species and all the essential and unquantified services provided by the forest such as controlling the climate will be lost. There is the need to understand where the tree seeds produced annually (Dike, 2001) are stored. This paper reports the soil seed stock in a swampy soil and a plantation of *Hevea brasiliensis* at Umudike, Nigeria. This is very crucial

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because most tree seedlings are produced from seeds. The result will be useful to foresters and environmentalist.

MATERIALS AND METHODS

Study area

The study was carried out at the swampy area of river Anya. The *Hevea brasiliensis* plantation has a common boundary with the swampy area. They are located at the University of Agriculture, Umudike, Nigeria. Before the establishment of the University in 1993, parts of the swampy area of the National Root Crop Research Institute (NRCRI) Nigeria, behind the dam were protected from human interference since 1960. Umudike lies between latitudes $05^0\ 27^1$ and $05^0\ 32^1$ N and longitudes $07^0\ 30^1$ and $07^0\ 50^1$ E. The climate is of the equatorial type. The minimum and maximum air temperatures range between 19.00 and 35^0C. The minimum and maximum soil temperatures range between 18^0C and 45^oC (Dike, 2003). The humidity is high and above 60 percent at night. However, the humidity could be as low as 45 percent between1330 and 1500 GMT during the peak of the local dry Harmattan period. There are two seasons: a wet and a dry seasons. The wet season starts from mid-March and ends in mid-November. The dry season continuous till the mid-March of the following year. The total annual rainfall ranges between 1500 and 3000 mm.

The vegetation is tropical rainforest (White, 1983). The original rainforest has been destroyed and in most places degraded secondary forest regrowths of various ages exist. The abundant tree species are *Anthonotha macrophylla*, *Dactyladenia barteri*, *Dialium guineense*, *Elaeis guineensis*, *Pentaclethra macrophylla and Piptadeniastrum africanum.* In some forest reserves, poorly stocked plantation of *Coffea arabica*, *Gmelina arborea*, *Hevea brasiliensis*, *Nauclea diderrichii* and *Tectona grandis* exist. Presently, emergent tree species are rare in abandoned farmlands. The topography is gentle and in most places the soil is sandy clay loam (Federal Department of Agriculture and Land Resources, (FDALR), 1990). The soil is deep and in many places without stones. The soil parent material is the Pre-Cambrian Basement Complex.

Methodology

Reconnaissance surveys of both the swampy area and the *Hevea brasiliensis* plantation were done. A 30 hectare area was marked out behind the NRCRI dam using trace lines and wooden pegs. Each hectare was numbered. A total of 8 hectares out of the 30 hectares was selected at random. The 25 hectares *Hevea brasiliensis* plantations were divided into 25, one hectare plots. From these, 8 hectares were selected at random. At each month, soil monoliths were collected from the swampy area and the *Hevea brasiliensis* plantation. The collection was from the centers of four one-hectare sample plots from 0.00 to 10.0 cm and 10.00 to 20.00 cm depths. Each soil monolith measured 50.0 cm x 25.0 cm x 10.0 cm and was placed in a numbered wooden box measuring 50.0 cm x 25.0 cm x 12.0 cm. Each box was placed on 1.0 meter platform and watered every morning and evening. The eight soil monoliths collected per month were grouped into two; one set was kept in the open and the other set in the shade provided by *Mangifera indica.* Soil monoliths were collected on the 15 November 2007, 15 December 2007, 15 January 2008 and 15 February 2008. The number of plant species germinated from the soil monoliths were recorded weekly. They were identified to species level at the Departmental Herbarium.

Simultaneous reading of the temperatures at the open and shade were carried out using thermometers. The red, far-red and the ratio red to far red in the open and under the shade were measured using Skye light meter SKR 100 (06903194) and the sensor SKR 110 (06903193). The plant species were tabulated into their families and classified into their relative abundance and percent frequency of occurrence. Analysis of variance was done firstly to test if there is significant difference between the number of seeds that germinated monthly; and secondly to test if there is significant difference between the number of seeds stored in the different depths.

RESULTS AND DISCUSSIONS

The readings of the red, far red and temperature taken at the open and under the shade at the University of Agriculture, Umudike where the seeds germinated from soil monoliths were studied are in (Table-1). The readings of red and far red increased with sun rise but the ratio red to far red ranged between 1.00 and 2.05. A similar range of red to far red ratio was recorded by Dike (2009). At anytime within the day, reading of temperature was higher in the open than at the shade. Also the fluctuations in temperature at the open were pronounced between 1200 and 1400 GMT. The fluctuations could have assisted plant seeds having hard seed coat to break and germination to start. It was observed that the recorded temperatures of the soil monoliths were adequate for seed germination.

The list of plant species germinated from soil monoliths taken from the depth of between 0.00 and 10.0 cm and 10.0 to 20.00 cm from the swampy area of River Anya at Umudike, Nigeria is in Table-2. A total of 9 plant families comprising 18 plant species with 3417 individual were germinated within the four months of study from soil monoliths kept in the open. Of the nine plant families, the families represented by one plant species formed 66.67 percent. However, the families Cyperaceae and Poaceae were each represented by five plant species. There were no tree seeds that germinated. It was only sedges, grasses, ferns and climbers that were recorded. It was observed that fruits bearing indigenous tree species whose seeds are dispersed by explosive mechanism such as *Pentaclethra macrophylla* were not within 200 m from the swampy area resulting in the absence of their seeds at the swampy area. The plant species with over 80 percent frequency of occurrence were *Alternanthera sessilis* (100%), *Calopogonium mucunoides* (87.5%), *Scleria verrucosa* (100%) and *Pentodon pentandrus* (100%). The most relative abundant species were *Alternanthera sessilis*

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(30.29%), *Fimbristylis littoralis* (24.88%), *Scleria verrucosa* (23.88%) and *Pentodon pentandrus* (14.87%).

From the soil monoliths kept at the shade, five plant families consisting of seven plant species with 264 individuals were recorded. Except the family Cyperaceae which was represented by two plant species, all the other families were each represented by one plant species. (Table-2). Three plant species *Fimbristylis littoralis* (87.5%), *Scleria verrucosa* (100%) and *Pentodon pentandrus* (87.5%) had over 80 percent frequency of occurrence. The most relative abundance plant species were *Scleria verrucosa* (36.36%) and *Pentodon pentandrus* (33.3%).

The list of seeds germinated from soil monoliths taken from the *Hevea brasiliensis* plantation is in Table-3. Seeds of 12 plant families consisting of 15 species and 136 individuals germinated from soil monoliths kept in the open. The families Convolvulaceae and Cyperaceae were each represented by two genera. The rest were represented by one genus (Table-3). Germinated seeds were those of trees, climbers, grasses and sedges. The most frequently occurring plant species was *Baissea axillaris* (62.5%). The most relative abundant plant was *Axonopus compressus* (57.35%). In the 10 - 20.0 cm depth, eight plant families comprising nine genera and 60 individuals were recorded. The family Convolvulaceae was represented by two genera while the remaining families were each represented by one genus. Of the seeds that germinated, 93 percent germinated from soil monoliths kept in the open while seven percent germinated from soil monoliths kept in the shade. The difference could have been because light rich in red wavelength of light enhances germination. The light passing through the canopy of *Mangifera indica* could have been poor in red wavelength (Table-1).

There is significance difference ($P<0.05$) between the number of seeds germinated at the depths 0.0 to 10.0 cm and 10.00 to 20.00 cm. Many seeds that were germinated from the soil depth 0 - 10.0 cm could be attributed to the relatively large size of the seeds compared to the size of soil particles. Dike, (2009) observed that out of the 25 tree seeds he measured at Umudike, Nigeria, all the seeds were more than 1.52 mm in width. It then becomes very difficult for tropical tree seeds to enter the soil unaided because two particles of sand that are lying together have between 0.02 um and 2.00 um; two particles of clay lying together have less than 0.002 um and two particles of silt lying together have between 0.002 and 0.02 um. Moreover, some phyllosilicate clay minerals have layer thickness of between 0.714 and 1.106 nm (Olson, Thompson and Wilson, 2000). The observation is in line with that of Holthuijzen and Boerboom (1982). They found seeds of *Cecropia obtusa* and *Cecropia sciadophylla* mainly at 1cm of soil depth. Moreover many climax plant species seeds such as *Entandrophragma utile* having wing find it very difficult to enter into the soil, because of their surface area and little weight of the seeds. Hladik and Miquel (1990) recorded that large seeds are dispersed by elephants while monkeys and large birds disperse small seeds. Presently, elephant, birds and monkeys are more or less frequent at National Parks and very rare in abandoned farmlands outside reserved areas. According to Dike, (2000), many tree seeds fall within 200 m from the centre of the dispersing tree species and would be scarce outside that range. From the soil monoliths collected at the swampy area, a total of 1293, 1133,797 and 458 seeds germinated from soil monoliths in the months of November, December 2007 and January and February 2008, respectively. From the soil monoliths collected at the *Hevea brasiliensis* plantation a total of 95, 39, 50 and 12 seeds were germinated in the four months (Table-4). Most seeds were dispersed during the early dry season. Consequently, November had the highest number of seeds germinated from the soil monoliths. Seeds of some tree species such as *Khaya ivorensis*, *Irvingia gabonensis*, *Entandrophragma cylindericum* and *Gossweilerodendon balsamiferum* were not germinated from the monolith because of the absence of any fruiting tree near the area of study and the large size of the seeds. According to Dike, (1992) some tree seeds such as those of the genera *Entandrophragma*, *Strombosia* and *Triplochiton* produce seeds that if exposed to favorable conditions for seed germination the seeds would germinate within 40 days after seed dispersal. These have seedling banks. It then becomes very difficult for most of their seeds to enter upto the depth 10 - 20 cm before they germinate. Soil structure according to the type could be fine grain, granular, blocky, columnar, platy and massive and the pore size distribution ranged between Cryptopores (< 0.1 um) and Macropores (>75 um) (Kay and Angers, 2000). Consequently, silvicultural experiments based on their seed being stored in the soil might fail if they are not dust seeds (Burrows, 1975).

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Table-1. Readings of temperature, red, far red and the ratio red to far red at the open and under the shade of *Mangifera indica* at Umudike Nigeria.

Local time	In the open				Under the shade of *Mangifera indica*			
	Temperature (^{0}C)	Red	Far red	Ratio	Temperature (^{0}C)	Red	Far red	Ratio
6.00	23	-0.5	-0.48	1.0	23	-0.35	-0.68	1.0
7.00	23	1.25	-0.00	1.0	23	-0.37	-0.84	1.0
8.00	24.5	24.4	11.0	1.17	23	0.2	0.01	1.07
9.00	25	22.4	8.5	2.17	24	4.2	1.5	1.35
10	28	37.1	16.0	2.05	26	23.9	12	1.79
11	31	74.1	30.9	1.97	29	60.3	30.9	1.95
12	30	80.4	42.5	1.94	27.5	39	15.5	1.96
13	29	13.24	7.14	1.96	29	28.3	14.5	1.96
14	31	52.3	15.3	2.02	30	61.5	31.3	2.01
15	31	22	9.8	1.96	29	19.3	9.7	1.91
16	31	12.2	2.09	1.96	27	8.72	4.16	1.92
17	32	18.1	8.4	2.02	27	52.28	2.4	1.93
18	27	18.7	8.5	1.96	25	5.00	2.1	1.92

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Table-2. The number of seeds of plant species germinated from soil monoliths taken from the swampy area of river Anya at Umudike, Nigeria.

Monoliths kept in the open		**Depth 0.00 - 10.00cm No. of seeds germinated per month**				**10.00 - 20.00 cm No. of seeds germinated per month**				**Total**	**% frequency of occurrence**	**% relative abundance**
Family	**Species**	**Nov.**	**Dec.**	**Jan.**	**Feb.**	**Nov.**	**Dec.**	**Jan.**	**Feb.**			
Amaranthaceae	*Alternanthera sessilis* herb	181	321	279	87	109	25	19	14	1035	100	30.29
Asteraceae	Emilia coccinea herb	6								6	12.5	0.17
Athyriaceae	Diplazium sammati fern	1	3	6	1		2		1	14	87.5	0.41
Convolvulaceae	*Ipomoea aquatica* climber	2								2	12.5	0.06
Cyperaceae	*Cyperus haspan sedge*	4				5				9	25	0.26
	Fimbristylis littoralis sedge	167	207	82	56	159	118	53	8	850	100	24.88
	Kyllinga erecta sedge			1			2			3	25	0.09
	Mariscus longibracteatus sedge	5				2				7	25	0.20
	Scleria verrucosa sedge	175	244	169	32	132	39	20	5	816	100	23.88
Mimosoideae	*Mimosa pigra shrub*			1						1	12.5	0.03
Papilionoideae	*Centrosema pubescens climber*			2						2	12.5	0.06
	Calopogonium mucunoides climber		8	1	1	1	3	1	1	16	87.5	0.47
Poaceae	*Acroceras zizanioides grass*	16					8			24	25	0.70
	Eleusine indica grass	1								1	12.5	0.03
	Oryza barthii grass	1								1	12.5	0.03
	Panicum maximum grass			30	41	17		15	10	113	62.5	3.31
	Paspalum polystachyum grass	4	4	1	1		1			9	62.5	0.26
Rubiaceae	*Pentodon pentandrus herb*	158	51	42	99	108	12	9	29	508	100	14.87
	Total	721	836	614	318	533	210	117	68	3417		100
	Number of species germinated	13	7	11	8		9	6	7	18		
Monoliths kept under shade		**Depth 0.0 - 10.00 cm No. of seeds germinated per month**				**10.00 - 20.00 cm No. of seeds germinated per month**						
Amaranthaceae	*Alternanthera sessilis* herb	20	2	2	13		4		1	9	50	3.41
Athyriaceae	Diplazium sammatii fern	2	4	4	7	6	6			41	62.5	15.53
Cyperaceae	*Fimbristylis littoralis sedge*	3		1	7	1	1	11	5	28	87.5	10.61
	Fimbristylis littoralis sedge		47	11	4	5	19	6	1	96	100	36.36
Poaceae	*Oryza barthii grass*	1		3				3		6	25	2.27
	Perotis indica herb	1								1	12.5	0.38
Rubiaceae	*Pentodon pentandrus herb*	27	6	10	16		4	15	31	88	87.5	33.33
	Total	5	59	31	34	12	28	35	38	264		100
	Number of plant species		4	6	4	3	3	4	4	7		

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Table-3. The number of seeds of various plant species that germinated monthly both in the open and shade from soil monoliths taken from *Hevea brasiliensis* plantation at Umudike, Nigeria.

Monoliths in the open		**Depth 0.00 - 10.00 cm No. of seeds germinated per month**				**10.00 - 20.00 cm No. of seeds germinated per month**				**Total**	**% frequency of occurrence**	**% relative abundance**
Family	**Species**	**Nov.**	**Dec.**	**Jan.**	**Feb.**	**Nov.**	**Dec.**	**Jan.**	**Feb.**			
Annonaceae	*Uvaria chamae* tree	1								1	21.5	0.730
Apocynaceae	*Baissea* auxillaris climber	1	1	1	1				1	5	62.5	3.650
Asteraceae	*Emilia coccinea* grass		1	14						15	25.0	10.949
Caesalpinioideae	*Griffonia simplicifolia* climber				1	1	1			3	32.5	2.190
Convolvulaceae	*Ipomoea involucrate* climber			1	1		1	1		4	50	2.920
	Neuropeltis acuminate climber	2								2	12.5	1.460
Cyperaceae	*Mariscus alternifolius* sedge	2	4			1	1			8	50.0	5.839
	Scleria verrucosa sedge	2	2		2			2		8	50.0	5.839
Dioscoreaceae	*Dioscorea cayenensis* climber			2				1		3	25.0	2.190
Euphorbiaceae	*Macaranga barteri* tree			2		1				3	25.0	2.190
Hypericaceae	*Harungana madagascariensis* tree		1							1	12.5	0.730
Icaciniaceae	*Icacinia trichantha* climber					1				1	12.5	0.730
Papilionoideae	*Centrosema pubescens* climber		1	1						2	12.5	1.460
Poaceae	*Axonopus compressus* grass	63	8			7				78	25	56.934
	Panicum maximum grass		1					1		2	12.5	2.190
	Total		19	21	5	11	3	5	1	136		100
Monoliths under shade		**Depth 0.0 - 10.00 cm No. of seeds germinated per month**				**10.00 - 20.00 cm No. of seeds germinated per month**						
Acanthaceae	*Brillantaisia lamium*		7	6	3		4	4	1	25	75	41.67
Annonaceae	*Uvaria chamae* tree	1	2	2						5	37.5	8.33
Caesalpinioideae	*Griffonia simplicifolia* climber			1						1	12.5	1.67
Convolvuaceae	*Ipomea involucrata* climber			4						4	12.5	6.67
	Neuropeltis acuminata climber		2							2	12.5	3.33
Dioscoreaceae	*Dioscorea cayenensis* climber	1		1						2	25.0	3.33
Euphorbiaceae	*Hevea brasiliensis* tree	1	1	1					1	4	50.0	6.67
Papilionoideae	*Abrus pracatorius* climber	7	1	3		2		1	1	15	62.5	25.0
Poaceae	*Cynodon dactylon* grass	1						1		2	25.0	3.33
	Total	11	13	18	3	2	4	6	3	60		100

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Table-4(A). The number of viable seeds germinated from soil monoliths from both the swampy area of river Anya and the *Hevea brasiliensis* plantation at Umudike, Nigeria.

(A). Viable seeds germinated from the swampy area.

Site	Depth in cm	Months				
		2007 Nov.	2007 Dec.	2008 Jan.	2008 Feb.	Total
Open	0.0 - 10.0	721	836	614	318	2489
Open	10.0 - 20.0	533	210	117	68	928
Shade	0.0 - 10.0	27	59	31	34	151
Shade	10.0 - 20.0	12	28	35	38	113
Total		1293	1133	797	458	3681

Table-4(B). Viable seeds germinated from *Hevea brasiliensis*.

Site	Depth in cm	Months				
		2007 Nov.	2007 Dec.	2008 Jan.	2008 Feb.	Total
Open	0.0 - 10.0	71	19	21	5	116
Open	10.0 - 20.0	11	3	5	1	20
Shade	0.0 - 10.0	11	13	18	3	45
Shade	10.0 - 20.0	2	4	6	3	15
Total		95	39	50	12	196

CONCLUSIONS AND RECOMMENDATIONS

Many seeds are stored on top of the soil. Large seeds find it difficult to enter into the soil matrix except when they are assisted by rats, pigs and animals that dig holes or are pressed into the soil by large animals such as *Loxodonta africana cyclotis* (elephant) *or Syncerus caffer* (buffalo). Some of these animals are few outside National parks. Consequently, seeds of emergent and upper canopy tree species were not germinated at either the swampy area or *Hevea brasiliensis* plantation. These areas needed the introduction of seedlings of desirable plant species or the swampy area would remain covered by sedges, grasses and ferns for a long time. The *Hevea brasiliensis* plantation, when it is abandoned would revert to degraded secondary forest with few trees listed as economic, (Lancaster, 1961).

It is recommended that government ought to build and maintain more schools of Forestry, employ the graduates, insist on the number of hectares to be planted and maintained per year; and intensify research on natural regeneration methods. Many early silvicultural experiments such as the Group method; (Kennedy, 1935); the Tropical Shelterwood System (Lowe, 1975) based on the fact that economic tree seeds would be dispersed into the opening created, should be re modernized and tried. It is known that everybody cannot plant a tree well. These trees that transpire water vapor and oxygen into the atmosphere and serve as carbon sink should be planted or their absence would result in lack of the functions of the forest. Without the trees the climate could change. It is recommended that countries that cannot have over 20 percent of their land area covered by well stocked forest should pay a reasonable fine annually until the country has completed planting up the area.

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