

SOIL SEED BANK DYNAMICS IN *TITHONIA DIVERSIFOLIA* DOMINATED FALLOWLAND VEGETATION IN ILE-IFE AREA OF SOUTHWESTERN NIGERIA

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Abstract. *The soil seedbank of Tithonia diversifolia, an invasive species which dominates open waste fallowland vegetation was studied. Two different roadside sites which vary in extent of open waste land were selected. The species composition of the established vegetation was assessed in the two different sites. Twenty top soil samples were collected at five different distances (15cm, 30cm, 45cm, 60cm, and 75cm) inwards away from each main road in dry and rainy seasons and the seed bank composition was determined by greenhouse germination over a 6month period. The similarity between the composition of the seed bank flora and that of the established vegetation was low. The least and the highest emerged seedlings density was recorded in the 15metres and 75metres respectively inwards away from the main road in both seasons. The results of the seedlings emergence is a reflection of the extent of open waste land dominated by the invasive species due to human disturbance (road construction) on both sites. Overall results suggest that the emergence of the species from the soil seed bank may be due to the impact of the invasive species – Tithonia diversifolia on other plant species in the study environment.*

Keywords: Invasive species, fallowland, seedling emergence, soil seed bank, *Tithonia diversifolia*.

INTRODUCTION

The introduction of plant species into a new environment deliberately or otherwise can have many unanticipated ecological effects (Howard and Harteminkl (2000). These introduced species otherwise called invasive species can have devastating effects on ecosystem quality and functioning as they often time out-compete indigenous or native species thereby leading to the extinction or disappearance of an endemic species (Lorence and Suesman, 1986). The threat to biodiversity due to invasive alien species is considered second only to that of habitat destruction. Invasive species cause loss of biodiversity including species extinction, and changes in hydrology and ecosystem function. Thus, invasive species are a serious threat to conservation and sustainable use of biodiversity with undesirable impacts on the services provided by the ecosystem (Raghubanshi *et.al.*2005). Invasive species/plants such as *Tithonia diversifolia* have been shown to impede both ecological and conservation studies (Adebowale and Olorode 2005). The mechanism by which invasive species affect native communities may include competition, altered ecosystem processes or other pathways like allelopathy or

phytotoxicity (Samuel *et al.*, 2005). Invasive species have been reported to affect seedlings emergence of native species to varying degree (Samuel *et al.*, (2005). Similarly, Samuel *et al.*, (2005) reported that extracts from parts of certain invasive species affected seedling emergence time, leaf biomass of native tree seedlings to varying degrees in the native species.

In Nigeria, especially in the lowland rainforest as well as in other habitats, these exotic/alien species especially *Tithonia diversifolia* now dominate a sizeable portion of the secondary fallow vegetation. Invasive species cause a reduction in native biodiversity through negative effect on the recruitment and persistence of native plant species (Pagad and Browne, 2008). They tend to be highly successful as judged, in part by their ability to produce abundance of seeds that are in some cases may be a life long in the soil seed bank. The invasion of the tropical rainforest landscape of Nigeria by *Tithonia diversifolia* is generating a lot of concern in view of their aggressive growth rate, heavy seed production and allelopathy.

In this work we focused our efforts on the role of *Tithonia diversifolia* in secondary fallowland vegetation dynamics and in potential of a community for restoration/regeneration from soil seed bank. The aim of this study is to (1) determine the density and dynamics of germinable seeds in the soil seed bank of secondary fallowland of *Tithonia diversifolia* dominated environment in relation to season. (2) to assess the relationship between the composition of the established vegetation and the seed bank (3) to determine the effect of extent of disturbed/fallowland due to human disturbance such as road construction colonised by *Tithonia diversifolia* on seedling emergence in the study sites.

MATERIAL AND METHOD

The study sites are the secondary fallowland vegetation (due to human disturbance by road construction) dominated by *Tithonia diversifolia* along Ife – Ibadan dual carriage way ($07^{\circ} 29.919'N$; $004^{\circ} 26.871E$) and Ife – Ilesa single lane highway ($07^{\circ} 31.866'N$; $004^{\circ} 34.424'E$) in Ile-Ife area of Southwestern Nigeria. The study was carried out between 2006 and 2007. The mean annual rainfall of 1400mm (five year mean) has been reported for Ile-Ife (Oke and Isichei, 1997). The soils of the study sites have been classified as Iwo series (Smyth & Montgomery, 1962) while the vegetation is lowland rainforest. In each of two study sites, soil samples were collected in two occasions, before and during rainy season, i.e. March and July 2006 respectively. Soil samples were taken, using soil auger (diameter 8.5cm) at a depth of 0-15cm. The soil samples were randomly collected from distances, 15, 40, 45, 60 and 75m inward away from the roadside to the forest edge across the secondary fallowland vegetation. The soil samples were then packed, labelled and transferred to the laboratory at the Department of Botany, Obafemi Awolowo University, Ile-Ife, Nigeria where they were spread in the laboratory tables and air-dried.

The soil samples put in containers for seeds germination under nursery conditions. Germinated seeds were observed, identified and counted daily up to six months. Emerged seedlings were identified as trees/shrubs, herbs and grasses. The

seedlings were removed after counting and identification to facilitate further germination and counting. The identification followed Hutchinson and Dalziel (1954-72) flora of west tropical Africa. Unidentified seedlings that were required for correct identification were uprooted and transplanted into bigger pots until proper identification could be carried out at IFE Herbarium. Number of emerged seedlings was obtained in each site and season. The percentage contribution of each species to the soil seed bank was also determined seasonally. Similarity indices (based on Sorenson's index) was also used to compare the similarity in species composition (standing vegetation and seed bank) among the two study sites. A two way Analysis of Variance (ANOVA) was used to compare the soil seed bank density per site for the two seasons.

RESULTS AND DISCUSSION

SPECIES COMPOSITION OF THE STANDING VEGETATION

The standing vegetation species composition of the two study sites is presented in Table 1. Thirty-two (32) plant species belonging to 22 families were encountered in the standing vegetation in the two sites and the species were predominantly shrubs and herbaceous species. The list also reveals the presence of nine (9) woody species (28.1%), grass species (9.4%) and twenty herbaceous species (62.5%). A low level of similarity (40%) exists between the standing vegetation of the two study sites using similarity analysis (Sorenson 1948). The eight (8) common plant species in the standing vegetation at the two study sites are : *Andropogon tectorum*, *Bracharia deflexa*, *Desmodium scorpiurus*, *Phyllanthus amarus*, *Sida acuta*, *Spigellia anthelmia*, *Trema orietalis* and *Tithonia diversifolia*.

Table 1

Plant species composition of the standing vegetation of the study plots.

Species	Family	Site 1	Site 2
<i>Andropogon gayanus</i>	Poaceae	+	+
<i>Aspilia helianthus</i>	Asteraceae	+	-
<i>Bracharia deflexa</i>	Poaceae	+	+
<i>Cassia hirsuata</i>	Caesalpiniaceae	+	-
<i>Chromolaena odorata</i>	Asteraceae	+	-
<i>Cnetis feruginea</i>	Connaraceae	-	+
<i>Combretum platypterum</i>	Combretaceae	-	+
<i>Deinbollia pinnata</i>	Sapindaceae	+	-
<i>Desmodium scorpiurus</i>	Fabaceae	+	+
<i>Euphorbia heterophylla</i>	Euphorbiaceae	+	-
<i>Euphorbia hirta</i>	Euphorbiaceae	+	-
<i>Ficus exasperata</i>	Moraceae	-	+
<i>Icacina trichantha</i>	Icacinaceae	-	+
<i>Indigofera pulcra</i>	Papilionaceae	+	-
<i>Ipomea involucrata</i>	Convolvulaceae	-	+
<i>Mallotus oppositifolium</i>	Euphorbiaceae	+	-
<i>Mimosa pudica</i>	Mimosaceae	+	-
<i>Mucuna pruriens</i>	Papilionaceae	-	+

Continuation of Tabel 1			
Species	Family	Site 1	Site 2
<i>Newbouldia laevis</i>	Bignoniaceae	+	-
<i>Pandiacia spp</i>	Amaranthaceae	+	-
<i>Panicum maximum</i>	Poaceae	-	+
<i>Phyllanthus amarus</i>	Euphorbiaceae	+	+
<i>Salacia celastraceae</i>	Celastraceae	-	+
<i>Sida acuta</i>	Malvaceae	+	+
<i>Spigelia anthelmia</i>	Loganiaceae	+	+
<i>Spondia mombin</i>	Anarcadiaceae	+	-
<i>Talinum triangulare</i>	Portulacaceae	+	-
<i>Tephrosia bracteolata</i>	Papilionacea	+	-
<i>Trema orientalis</i>	Ulmaceae	+	+
<i>Trianthema portulacastrum</i>	Aizoaceae	+	-
<i>Tridax procumbens</i>	Asteraceae	+	-
<i>Tithonia rotundifolia</i>	Asteraceae	+	-
- = Not available		+ = Available	

SPECIES RICHNESS AND DENSITY OF SOIL SEED BANK.

The species composition of the soil seed bank of the two study sites is presented in Table 2. In the study site 1 (Ife-Ibadan road), in the rainy season sampling, a total of 359 seedlings (6328 seed/m²) emerged in this study site in all the periods of the germination studies (Table 2). Twenty six (26) species emerged containing only one woody species (*Trema orientalis*). *Tithonia diversifolia* had the highest seedling density of 87 seedlings (1533 seeds/m²) or 24.2% of the total seed density of the soil seed bank. *Oldenlandia corymbosa* had the second highest seedling density of 60 seedlings (1057 seeds/m²) or 16.7 % of the total seed density of the soil seed bank. Eight (8) species namely *Ageratum conyzoides*, *Ceratopteris cornuta*, *Diodia scandens*, *Ipomoea triloba*, *Mimosa pudica*, *Paulinia pinnata*, *Trema orientalis* and *Urena lobata* had only one seedling each (18 seeds/m²) or 0.3% emerged from the seed bank and other species had intermediate values. Two species were the unidentified species encountered in this study site 1.

In the dry season sampling 898 seedlings (15822 seeds/m²) emerged in all the months of the germination studies. Twenty-seven (27) species emerged from this study site 1 and only two plant species were unidentified. *Oldenlandia corymbosa* had the highest seedling density of 276 seedlings (4863 seeds/m²) or 30.7% of the seed density of the seed bank (Table 2). *Tithonia diversifolia* seedlings also featured prominently in the seed bank with 193 seedlings (3401 seeds/m²) or 21.4% of the seed bank density. Species such as *Ageratum conyzoides*, *Euphorbia heterophylla* and *Physalis angiculata* had one seedling (18seeds/m) each, representing 0.1% of the seedbank while other species had intermediate values.

In the study site 2 and in the dry season sampling, 1537 seedling (27087seed/m) emerged (Table 2). A total of 22 species emerged consisting of only one woody species: *Trema orientalis* as well as two unidentified species. *Bracharia deflexa* recorded the highest seedling density of 429 (7559 seed/m) or 27.9% and

closely followed by *Chromolaena odorata* 388 seedlings (6837 seeds/m) or 25.2% of the seed bank density while five species namely *Ceratopteris cornuta*, *Ipomoea involucrata*, *Larportea aestuans*, *Trema orientalis* and one of the unidentified species had the least seedlings emergence density of one seedling (18 seeds/m). *Tithonia diversifolia* also had a seedling emergence density of 25 seedlings (441 seeds/m) or 1.6% of the seedbank density of the study site.

In the rainy season sampling a total of 311 seedlings (5481 seeds/m) emerged in the study site (Table 2) consisting of 19 species, two of which were unidentified. One woody species (*Trema orientalis*) emerged in this soil sample. *Bracharia deflexa* had the highest seedling density of 138 or 2432 seeds/m representing 44.4% of the total density of the seed bank. *Chromolaena odorata* recorded the second highest seedling density with 42 seedlings (740 seeds/m) or 13.5% of the seed bank density. *Tithonia diversifolia* contributed 24 seedlings (423 seeds/m) or 7.7% of the seed bank density. However, six (9) species: *Ageratum conyzoides*, *Euphorbia hirta*, *Laportea aestuans*, *Physalis anguculata*, *Securinega virosa* and *Sida veronicifolia* had the least seedling density of one (01) or 18 seeds/m each emerged from the seedbank while the other species had intermediate values.

The monthly seedlings emergence density in the dry season soil sample revealed that site 2 (Ife-Ilesa single lane) consistently had higher values than site 1 (Ife-Ibadan dual carriage way) but this difference is not significant (Fig.1). In the rainy season the same trend was observed (Fig.2). Comparison of seasonal seedlings emergence in the two study sites revealed that the soil sample of dry season had significantly ($P=0.05$) higher number of emerged species in both study sites than that of rainy seasons (see Table 2).

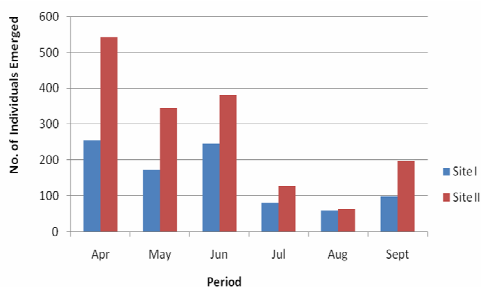


Fig.1: Monthly Seedlings Emergence Densities in The Dry Season in Sites I & II

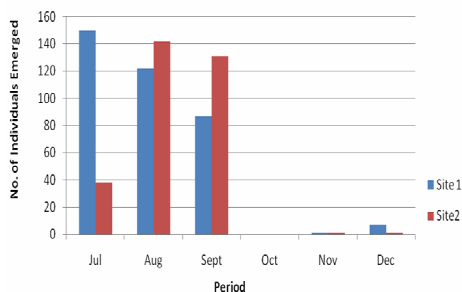


Fig. 2: Monthly Seedlings Emergence Densities in The Rainy Season in Sites I & II

SEEDBANK AND STANDING VEGETATION

The comparison of the species composition of seedbank and the standing vegetation revealed that in the study site 1 in the dry season samples, 13 species in the seed bank had representatives in the standing vegetation (41.9%) (Table 3).

Table 2

Density of species (seedlings/cm² and seeds/m²) that emerged from soil collection in the two study plots in both seasons (Rainy and Dry seasons)

S N	Species	SITE 1						SITE 2					
		Rainy season			Dry season			Rainy season			Dry season		
		s/cm ²	s/m ²	% C.S	s/cm ²	s/m ²	% C.S	s/cm ²	s/m ²	% C.S	s/cm ²	s/m ²	% C.S
1	<i>Ageratum conyzoides</i>	1	18	0.3	1	18	0.1	1	18	0.3	13	229	0.8
2	<i>Andropogon gayanus</i>	5	88	1.4	5	88	0.6	5	88	1.6	11	194	0.7
3	<i>Andropogon tectorum</i>	3	53	0.8	-	-	-	5	88	1.6	-	-	-
4	<i>Aspilia helianthus</i>	-	-	-	2	35	0.2	-	-	-	-	-	-
5	<i>Brachiraria deflexa</i>	34	599	9.5	187	3295	20.8	138	2432	44.4	429	7559	27.9
6	<i>Celosia trygna</i>	5	88	1.4	3	53	0.3	-	-	-	-	-	-
7	<i>Ceraptopteris cornuta</i>	1	18	0.3	2	35	0.2	-	-	-	1	18	0.1
8	<i>Chromolaena odorata</i>	22	388	6.1	17	300	1.9	42	740	13.5	388	6837	25.2
9	<i>Desmodium scorparius</i>	-	-	-	7	123	0.8	-	-	-	8	141	0.5
10	<i>Diodia scandens</i>	1	18	0.3	4	70	0.4	15	264	4.8	146	2573	9.5
11	<i>Euphorbia heterophylla</i>	25	441	7.0	1	18	0.1	-	-	-	3	53	0.2
12	<i>Euphorbia hirta</i>	4	70	1.1	5	88	0.6	1	18	0.3	-	-	-
13	<i>Euphorbia hyssopifolia</i>	-	-	-	14	247	1.6	-	-	-	-	-	-
14	<i>Ipomea triloba</i>	1	18	0.3	-	-	-	-	-	-	-	-	-
15	<i>Ipomea involucrata</i>	-	-	-	-	-	-	-	-	-	1	18	0.1
16	<i>Lantana camara</i>	10	176	2.8	3	53	0.3	-	-	-	24	423	1.6
17	<i>Laportea aestuans</i>	8	141	2.2	4	70	0.4	1	18	0.3	1	18	0.1
18	<i>Lindernia cristacea</i>	-	-	-	-	-	-	-	-	-	13	229	0.8
19	<i>Mimosa pudica</i>	1	18	0.3	3	53	0.3	-	-	-	-	-	-
20	<i>Oldenlandia corymbosa</i>	60	1057	16.7	276	4863	30.7	31	546	10.0	294	5181	19.1
21	<i>Oxalis corniculata</i>	-	-	-	-	-	-	-	-	-	3	53	0.2
22	<i>Paulinia pinnata</i>	1	18	0.3	-	-	-	-	-	-	-	-	-

Continuation of Tabel 2

23	<i>Peperomia pellucida</i>	2	35	0.6	5	88	0.6	10	176	3.2	-	-	-
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24	<i>Perotis indica</i>	-	-	-	2	35	0,2	-	-	-	-	-	-
25	<i>Phyllanthus amarus</i>	2	35	0,6	29	511	3,2	4	70	1,3	22	388	1,4
26	<i>Physalis anguculata</i>	-	-	-	1	18	0,1	1	18	0,3	-	-	-
27	<i>Portulaca oleracea</i>	7	123	2,0	13	229	1,4	-	-	-	6	106	0,4
28	<i>Securinega virosa</i>	-	-	-	-	-	-	1	18	0,3	-	-	-
29	<i>Sida veronicifolia</i>	-	-	-	-	-	-	1	18	0,3	-	-	-
30	<i>Spigelia anthelmia</i>	5	88	1,4	18	317	2,0	10	176	3,2	127	2238	8,3
31	<i>Talinum triangulare</i>	51	899	14,2	81	1427	9,0	-	-	-	7	123	8,3
32	<i>Tithonia diversifolia</i>	87	1533	24,2	193	3401	21,4	24	423	7,7	25	441	1,6
33	<i>Trianthema portulacastrum</i>	-	-	-	15	264	17	-	-	-	-	-	-
34	<i>Trema orientalis</i>	1	18	0,3	-	-	-	2	35	0,6	1	18	0,1
35	<i>Urena lobata</i>	1	18	0,3	-	-	-	-	-	-	-	-	-
36	Unidentified Y	4	70	1,1	2	35	0,2	17	300	5,5	13	229	0,8
37	Unidentified Z	17	300	4,7	5	88	0,6	2	35	0,6	1	18	0,1
		359	6328	100%	898	15822	100%	311	5481	100%	1537	27087	100%

s/cm²=seedlings/cm²; s/m²=seeds/m²; % c.s=% contribution of each species.

Table 3

Comparison of species composition and Similarity indices (based on Sorenson index) between the seedbank and the standing vegetation of the two study sites in dry and rainy seasons.

	SITE 1					SITE 2				
	N° of species in the standing vegetation (SV)	N° of species in Seedbank (SB)	Species common to SV and SB(CS)	Sorenson Index of similarity between SV and SB	Sorenson Index of similarity of SB of dry and Raining seasons	N° of species in the standing vegetation (SV)	N° of species in Seedbank (SB)	Species common to SV and SB (CS)	Sorenson Index of similarity between SV and SB	Sorenson Index of similarity of SB of dry and Raining seasons
Dry season	23	27	13	48,1	72,4	17	22	8	34,8	61,9
Raining season	23	26	12	44,0	72,4	17	19	5	26,3	61,9

Continuation of Tabel 2													
23	<i>Peperomia pellucida</i>	2	35	0.6	5	88	0.6	10	176	3.2	-	-	-
24	<i>Perotis indica</i>	-	-	-	2	35	0.2	-	-	-	-	-	-
25	<i>Phyllanthus amarus</i>	2	35	0.6	29	511	3.2	4	70	1.3	22	388	1.4
26	<i>Physalis anguculata</i>	-	-	-	1	18	0.1	1	18	0.3	-	-	-
27	<i>Portulaca oleracea</i>	7	123	2.0	13	229	1.4	-	-	-	6	106	0.4
28	<i>Securinega virosa</i>	-	-	-	-	-	-	1	18	0.3	-	-	-
29	<i>Sida veronicifolia</i>	-	-	-	-	-	-	1	18	0.3	-	-	-
30	<i>Spigelia anhelmia</i>	5	88	1.4	18	317	2.0	10	176	3.2	127	2238	8.3
31	<i>Talinum triangulare</i>	51	899	14.2	81	1427	9.0	-	-	-	7	123	8.3
32	<i>Tithonia diversifolia</i>	87	1533	24.2	193	3401	21.4	24	423	7.7	25	441	1.6
33	<i>Trianthema portulacastrum</i>	-	-	-	15	264	17	-	-	-	-	-	-
34	<i>Trema orientalis</i>	1	18	0.3	-	-	-	2	35	0.6	1	18	0.1
35	<i>Urena lobata</i>	1	18	0.3	-	-	-	-	-	-	-	-	-
36	Unidentified Y	4	70	1.1	2	35	0.2	17	300	5.5	13	229	0.8
37	Unidentified Z	17	300	4.7	5	88	0.6	2	35	0.6	1	18	0.1
		359	6328	100%	898	15822	100%	311	5481	100%	1537	27087	100%

s/cm^2 =seedlings/cm²; s/m^2 =seeds/m²; % c.s=% contribution of each species.

Table 3

Comparison of species composition and Similarity indices (based on Sorenson index) between the seedbank and the standing vegetation of the two study sites in dry and rainy seasons.

	SITE 1					SITE 2				
	N° of species in the standing vegetation (SV)	N° of species in Seedbank (SB)	Species common to SV and SB (CS)	Sorenson Index of similarity between SV and SB	Sorenson Index of similarity of SB of dry and Raining seasons	N° of species in the standing vegetation (SV)	N° of species in Seedbank (SB)	Species common to SV and SB (CS)	Sorenson Index of similarity between SV and SB	Sorenson Index of similarity of SB of dry and Raining seasons
Dry season	23	27	13	48.1	72.4	17	22	8	34.8	61.9
Raining season	23	26	12	44.0	72.4	17	19	5	26.3	61.9

The species common to both the seed bank and the standing vegetation are: *Andropogon gayanus*, *Aspilia helianthus*, *Bracharia deflexa*, *Chromolaena odorata*, *Desmodium scorparius*, *Euphorbia heterophylla*, *Euphorbia hirta*, *Mimosa pudica*, *Phyllanthus amarus*, *Spigella anthelmia*, *Talinum triangulare* and *Trianthema portulacastrum*, with *Tithonia diversifolia* being the dominant species. However, for the rainy season sample in the study site 1, apart from *Tithonia diversifolia*, eleven (11) other species (40.7%) were represented in both the standing vegetation and the seed bank and these are: *Andropogon gayanus*, *Bracharia deflexa*, *Chromolaena odorata*, *Euphorbia heterophylla*, *Euphorbia hirta*, *Mimosa pudica*, *Phyllanthus amarus*, *Spigella anthelmia*, *Talinum triangulare*, *Trema orientalis* and *Urena lobata*.

In the study site 2, in the dry season samples, eight (8) out of the 23 species (34.8%) that emerged from the seed bank had representatives in the standing vegetation apart from *Tithonia rotundifolia* which was dominant species. These species are: *Andropogon gayanus*, *Bracharia deflexa*, *Desmodium scorparius*, *Ipomoea involucrata*, *Phyllanthus amarus*, *Spigella anthelmia* and *Trema orientalis*. 19 species emerged from the seed bank of study site 2 in the rainy season and only five (5) species (26.3%) were represented in the standing vegetation and these species are: *Andropogon gayanus*, *Bracharia deflexa*, *Phyllanthus amarus*, *Spigella anthelmia*, *Talinum triangulare* and *Trema orientalis*.

Comparison of the species composition of the seedbank (SB) and the standing vegetation (SV) of the two study sites within seasons using Sorenson index of similarity (1948) (Table 3) reveals that the level of similarity was generally low and it ranges from 26.3% in the rainy season for site 2 to 48.1% in the dry season for site 1. This result indicates that many of the species that emerged from seedbank were not represented in the standing vegetation. Furthermore, the species composition of the seedbank of each study site for the two seasons was subjected to similarity analysis (Sorenson1948) and the result reveals a high level of similarity, 72.4% for Site 1 and 61.9% for Site 2 (Table 3).

SEEDLING EMERGENCE IN RELATION TO EXTENT OF THE FALLOWLAND. The result of the seedling emergence in the 2 seasons and across the five distances show that for site 1 (Ife-Ibadan), the least and the highest seedling density was recorded in the 15 m and 75 m respectively inward away from the main road during the rainy season and the dry season (Table 4). Also for site 2 (Ife-Ilesa) the least and the highest seedling emergence came from 15 m and 75 m distance respectively during the dry season but the least and highest seedling emergence was observed in the 60 m and 75 m distance respectively during the rainy season (Table 5). The total seedling emergence for each distance and for each site was pooled together and were subjected to 2 way ANOVA, it shows a significant difference ($P=0.01$) in the seedling emergence density across the various distances. The

seedling densities of the two sites were also subjected to students' T-test. The result shows no significance change in seedling density between the two sites.

Table 4

Seedlings Emergence in relation to extent of the fallowland
in the study site 1 in both seasons

S N		Dry season						Rainy season					
		15m	30m	45m	60m	75m	Total	15m	30m	45m	60m	75m	Total
1	<i>Ageratum conyzoides</i>	1	-	-	-	-	1	-	-	-	-	1	1
2	<i>Andropogon gayanus</i>	-	-	5	-	-	5	-	-	-	1	4	5
3	<i>Andropogon tectorum</i>	-	-	-	-	-	-	-	1	2	-	-	3
4	<i>Aspilia helianthus</i>	-	-	-	-	2	2	-	-	-	-	-	-
5	<i>Brachiraria deflexa</i>	11	10	27	42	97	187	2	1	2	8	21	34
6	<i>Celosia trygna</i>	2	-	-	-	1	3	-	5	-	-	-	5
7	<i>Cerapopteris cornuta</i>	-	1	1	-	-	2	1	-	-	-	-	1
8	<i>Chromolaena odorata</i>	1	9	1	2	4	17	9	3	-	5	5	22
9	<i>Desmodium scorparius</i>	1	2	2	1	1	7	-	-	-	-	-	-
10	<i>Diodia scandens</i>	-	-	-	2	2	4	-	-	-	1	-	1
11	<i>Euphorbia heterophylla</i>	1	-	-	-	-	1	-	-	-	-	-	-
12	<i>Euphorbia hirta</i>	-	1	1	-	3	5	2	2	-	-	-	4
13	<i>Euphorbia hyssopifolia</i>	14	-	-	-	-	14	-	-	-	-	-	-
14	<i>Ipomea triloba</i>	-	-	-	-	-	-	-	1	-	-	-	1
15	<i>Ipomea involucrata</i>	-	-	-	-	-	-	-	-	-	-	-	-
16	<i>Lantana camara</i>	-	-	-	-	3	3	-	-	-	-	10	10
17	<i>Laportea aestuans</i>	-	1	-	-	3	4	-	-	1	1	6	8
18	<i>Lindernia cristata</i>	-	-	-	-	-	-	-	-	-	-	-	-
19	<i>Mimosa pudica</i>	3	-	-	-	-	3	1	-	-	-	-	1
20	<i>Oldenlandia corymbosa</i>	1	8	9	23	235	276	4	17	17	17	15	70
21	<i>Oxalis corniculata</i>	-	-	-	-	-	-	-	-	-	-	-	-
22	<i>Paulinia pinnata</i>	-	-	-	-	-	-	-	1	-	-	-	1
23	<i>Peperomia pellucida</i>	-	-	-	-	-	-	-	-	1	-	1	2
24	<i>Perotis indica</i>	-	-	-	-	2	2	-	-	-	-	-	-
25	<i>Phyllanthus amarus</i>	1	9	1	13	5	29	-	-	1	1	-	2
26	<i>Physalis angiculata</i>	-	-	1	-	-	1	-	-	-	-	-	-
27	<i>Portulaca oleracea</i>	-	2	9	-	2	13	-	1	6	-	-	7
28	<i>Securinega virosa</i>	-	-	-	-	-	-	-	-	-	-	-	-
29	<i>Sida veronicifolia</i>	-	-	-	-	-	-	-	-	-	-	-	-
30	<i>Spigelia anthelmia</i>	15	-	2	1	-	18	3	-	2	-	-	5
31	<i>Talinum triangulare</i>	-	24	20	-	37	81	2	8	23	2	16	51
32	<i>Tithonia diversifolia</i>	15	33	42	52	51	193	2	23	5	32	25	87
33	<i>Trianthema portulacastrum</i>	-	-	13	-	2	15	-	-	-	-	-	-
34	<i>Trema orientalis</i>	-	-	-	-	-	-	-	1	-	-	-	1
35	<i>Urena lobata</i>	-	-	-	-	-	-	-	-	-	-	1	1
36	Unidentified Y	-	-	-	2	-	2	-	-	-	4	-	4
37	Unidentified Z	1	-	1	-	3	5	-	1	4	3	9	17
		67	100	135	138	458	898	36	65	64	75	114	344

- = Not available

Table 5

Seedlings Emergence in relation to the extent of the fallowland
in the study site 2 in both seasons

S N		Dry season						Rainy season					
		15m	30m	45m	60m	75m	Total	15m	30m	45m	60m	75m	Total
1	<i>Ageratum conyzoides</i>	-	-	2	3	-	13	-	-	-	-	1	1
2	<i>Andropogon gayanus</i>	1	4	2	2	2	11	4	1	-	-	-	5
3	<i>Andropogon tectorum</i>	-	-	-	-	-	-	5	-	-	-	-	5
4	<i>Aspilia helianthus</i>	-	-	-	-	-	-	-	-	-	-	-	-
5	<i>Brachiraria deflexa</i>	38	56	123	71	141	429	10	14	63	16	35	138
6	<i>Celosia trygna</i>	-	-	-	-	-	-	-	-	-	-	-	-
7	<i>Cerapopteris cornuta</i>	-	-	-	-	-	-	-	-	-	-	-	-
8	<i>Chromolaena odorata</i>	27	55	28	60	218	388	15	1	4	4	18	42
9	<i>Desmodium scorparius</i>	-	-	1	4	3	8	-	-	-	-	-	-
10	<i>Diodia scandens</i>	10	23	16	36	61	146	6	6	1	-	2	15
11	<i>Euphorbia heterophylla</i>	-	-	-	1	2	3	-	-	-	-	-	-
12	<i>Euphorbia hirta</i>	-	-	-	-	-	-	-	-	1	-	-	1
13	<i>Euphorbia hyssopifolia</i>	-	-	-	-	-	-	-	-	-	-	-	-
14	<i>Ipomea triloba</i>	-	-	-	-	-	-	-	-	-	-	-	-
15	<i>Ipomea involucrata</i>	-	1	-	-	-	1	-	-	-	-	-	-
16	<i>Lantana camara</i>	1	1	1	6	15	24	-	-	-	-	-	-
17	<i>Laportea aestuans</i>	-	-	-	-	1	1	1	-	-	-	-	1
18	<i>Lindernia cristata</i>	3	2	2	4	2	12	-	-	-	-	-	-
19	<i>Mimosa pudica</i>	-	-	-	-	-	-	-	-	-	-	-	-
20	<i>Oldenlandia corymbosa</i>	6	5	6	184	93	294	2	11	2	-	16	31
21	<i>Oxalis corniculata</i>	-	-	1	-	2	3	-	-	-	-	-	-
22	<i>Paulinia pinnata</i>	-	-	-	-	-	-	-	-	-	-	-	-
23	<i>Peperomia pellucida</i>	-	-	-	-	-	-	8	-	-	2	-	10
24	<i>Perotis indica</i>	-	-	-	-	-	-	-	-	-	-	-	-
25	<i>Phyllanthus amarus</i>	2	3	7	6	4	22	2	-	-	-	2	4
26	<i>Physalis angiculata</i>	-	-	-	-	-	-	1	-	-	-	-	1
27	<i>Portulaca oleracea</i>	1	-	2	1	2	6	-	-	-	-	-	-
28	<i>Securinega virosa</i>	-	-	-	-	-	-	1	-	-	-	-	1
29	<i>Sida veronicifolia</i>	-	-	-	-	-	-	-	-	-	-	-	-
30	<i>Spigelia anthelmia</i>	3	4	14	43	63	127	3	2	-	1	4	10
31	<i>Talinum triangulare</i>	1	-	1	-	5	7	-	-	-	-	-	-
32	<i>Tithonia diversifolia</i>	8	4	11	-	2	25	-	-	3	-	21	24
33	<i>Trianthema portulacastrum</i>	-	-	-	-	-	-	-	-	-	-	-	-
34	<i>Trema orientalis</i>	1	-	-	-	-	1	-	-	1	-	-	1
35	<i>Urena lobata</i>	-	-	-	-	-	-	-	-	-	-	-	17
36	Unidentified Y	6	1	2	3	1	13	9	6	-	2	-	17
37	Unidentified Z	-	-	-	1	-	1	1	-	-	-	1	2
		109	159	219	425	625	1536	68	41	75	25	100	309

- = Not available

The low level of similarity observed in the standing vegetation of the two study sites using the similarity analysis (Sorenson, 1948) may be a reflection of the difference in species composition of the sites. This observation agrees with the report of Chandrashekara and Ramakrishna (1993) that the level of disturbance and successional ages of forest have effects on species composition. The presence of few woody species most of which are secondary regrowth forest species also indicates that the sites have been subjected to recent anthropogenic disturbances. The road construction activities has led to the destruction of the existing forest cover and the consequent invasion of the sites by secondary successional species and herbaceous species respectively. Hall and Okali (1979) have observed that the presence or dominance of early successional species is an indication of disturbance. Furthermore, the general dominance of the seedbank of the two study sites by herbaceous species is in agreement with the reports of many workers (Oke, *et al.*, 2006, Oladipo and Oke 2007).

The dominance of the soil seedbank by the seedlings of *Tithonia diversifolia* in site 1 as against site 2 is a reflection of the extent of human disturbance on both sites. Site 1 which is on a dual carriage road has recorded much more construction activities leading to more extensive open waste land in recent time than site 2 (a single lane) and consequently site 1 is more open to invasion by *Tithonia diversifolia* which Adebawale and Olorode (2005) described as having a wider spread across the ecological zones of Nigeria. Muoghalu and Chuba (2005) have also posited that *Tithonia diversifolia* species are plants of open sunny habitats. In agreement with Samuel *et al.* (2005) the spread of invasive *Tithonia diversifolia* in our local ecosystem leading to the replacement of native species/natural secondary fallow lands can potentially also accounted for the reduced number of seedlings of other species. The high rate of invasion by *Tithonia species* coupled with ease to colonise suitable open areas (like site 1) thus minimizing competition from other nearby plant species (Adebawale and Olorode, 2005), also growth rate is said to be remarkably fast as well as forming closely packed populations that tend to choke out 'timid' competitors.

A general lack of correspondence has also been reported for this study between the standing vegetation and the seedbank. This observation is almost a general trend in most soil seed bank studies and has been reported by other workers (Thompson and Grime 1979, Staaf *et al.* 1987). Very few of the total species that emerged as seedlings in the seedbank were represented in the standing vegetation. Similarly, Oke *et al.* (2006) reported a large discrepancy between soil seed bank and standing vegetation. This phenomenon reflects in this study and can be attributed to the fact that only few species are able to compete with *Tithonia diversifolia* in its domain where it is dominant and the possibility that germination requirements of these other/native species may not be fulfilled.

The seed bank density (5481-29615 seeds/m²) reported for these *Tithonia diversifolia* dominated sites is comparable to the figures given by other workers for similar disturbed environments, for example Oke *et. al* (2006) (6274-21872 seeds/m²), Oladipo and Oke (2007) (14115-21420 seeds/m²). However, the threat that the preponderance of *Tithonia* species posed to local flora, its reported production of phytotoxins or the allelopathic influence it has on neighbouring plant species (Ayeni *et al*, 1997) as well as its seed abundance in the seed bank has been observed as a factor that stabilizes *Tithonia* as a mono specific stand wherever it is found growing (Muoghalu and Chuba, 2005). This is possibly because it is capable of suppressing other species by outgrowing them (as tall as 5m) as well as the production of chemicals that inhibit the physiology of neighbouring species. The presence of *Trema orientalis* as the only woody species that emerged from the seedbank can be explained by the observation of Samuel *et al.* (2005) who have observed that invasive species pose a serious threat to native tree species because of the inhibiting effect that the extracts of the invasive species they used had on native tree seedlings. The effects of allelopathic / phytotoxic influences of species like *Tithonia* may have important consequences for forest community composition (biodiversity) and succession over time (Samuel *et al*, 2005). Similarly, allelopathic interactions between plants have been implicated in the patterning of vegetation and weed growth in agricultural systems (Baruah and Sarma 1994). The increase in seedling density during the dry season could be ascribed to the fact that most seeds in the soil seedbank met favourable environmental conditions to enhance their germination at this period, because favorable weather is a critical factor that determine the fate of seeds stored in the seedbank whether to germinate or remain dormant.

The increase in seedling emergence inwardly away from the road sides in both study plots is an indication that *Tithonia diversifolia* which is an aggressive invasive plant suppresses the presence of other native species by outgrowing them at distances close to the main road where *Tithonia spp* density is higher. Hence, many other species seedlings were encountered at distances far away inwardly from the main road where the influence of *Tithonia* was less. Akobundu and Agyakwa (1987) and Lordbanju (1991) reported similar report that *T. diversifolia* was found to be commonly associated with road sides, open and disturbed habitats and being absent from areas of mature plant establishments. The appearance and dominance of *Chromolaena odorata* (another early colonisers of waste lands) inwardly at distances more than 45 m is an indication that they are yet to be displaced by this invasive *T. diversifolia* at those distances. Overall, results suggest that the number of individuals and species that emerged from the soil seed bank may be due to the negative impact of *T. diversifolia* on other plant species and by their ability to produce abundance of seeds, that are in some cases may be a long life in the soil seed bank in the study environment.

REFERENCES

1. Adebowale A., O. Olorode (2005). An overview of the invasive potential of *Tithonia* species (Asteraceae) in Nigeria. *Science Focus*, 10(3): 65-69.
2. Akobundu I. O., C.W. Agyakwa (1987). *A Handbook of West African Weeds*. A publication of International Institute of Tropical Agriculture, Oyo Road, Ibadan, Nigeria. 521pp.
3. Ayeni A. O., O. T. Lordbanjou and B. A. Majek (1997). *Tithonia diversifolia* (Mexican sunflower) in South- western Nigeria: Occurrence and growth habit. *Weed Research*, 37(6): 443-449.
4. Baruah N. C., J. C. Sarma (1994). Germination and growth inhibitory sesquiterpene lactones and a flavone from *Tithonia diversifolia*. *Phytochemistry* 36(1):29-36
5. Chandrashekara U. M., P. S. Ramakrishnan (1993). Germinable Soil Seed bank dynamics during gap phase of a humid tropical forest in the Western Ghats of Keralla, India. *Journal of Tropical Ecology*, 9: 455-467.
6. Hall J.B and D. U. U. Okali (1979). A structural and floristic analysis of woody fallow vegetation near Ibadan, Nigeria. *Nigerian Journal of Ecology*, 67: 321-346.
7. Howard M. R, A. E. Hartemink (2000). Soil Seed bank and Growth rates of an invasive species, *Piper aduncum* in the low land of Papua New Guinea. *Journal of Tropical Ecology*, 16: 243-251.
8. Hutchinson, J., J. M. Dalziel (1954-72). Flora of West Tropical Africa (2nd Edition by R.W J Keay and F. N Hepper) Crown Agents for overseas Government, London.
9. Lordbanju O. T. (1991). *Studies on Mexican sunflower (Tithonia diversifolia (Hemsl.))*. A. Gray in *Southwestern Nigeria*. Unpublished M.Sc. Dissertation of the University of Ibadan, Ibadan.
10. Lorence D. H., R.W. Suesman (1986). Exotic species invasion into Mauritius wet forest remnants. *Journal of Tropical Ecology*, 2: 137- 162.
11. Moughalu J. I., D. K. Chuba (2005). Seed Germination and Reproductive strategies of *Tithonia diversifolia* (Hemsl) and *Tithonia rotundifolia* (P.M Blake). *Applied Ecology and Environmental Research*. 3(1): 39 - 46.
12. Oke S.O., A.O. Isichei (1997). Floristic Composition and Structure of the fallow vegetation in Ile- Ife Area of South Western Nigeria. *Nigerian Journal of Botany*, 10: 37-50.
13. Oke S.O., O.T. Oladipo, A.O. Isichei (2006). Seedbank Dynamics and Regeneration in a secondary lowland Rainforest in Nigeria. *International Journal of Botany*, 2(4): 363-371.
14. Oladipo O.T., S.O. Oke (2007). Seed bank Dynamics, Seedling Emergence and Survival of Herbaceous species in successional Plots in Ile Ife, South western Nigeria. *Research Journal of Botany*, 2(2): 76-85.
15. Pagad S., M. Browne (2008). Invasive Species Drive Biodiversity Loss. Worldwatch Institute. <http://www.worldwatch.org/node/5473> [Accessed 13th April, 2009]
16. Raghubanshi, A. S, Rai, L. C. Gaur, J. P. And Singh, J. S. (2005). Invasive alien species and biodiversity in India. *Current Science*, 88(4):539-540.
17. Samuel O.P., A.R. Jennifer, C. Keith (2005). Invasive Plants can Inhibit Native Tree Seedlings: Testing Potential allelopathic Mechanisms: *Plant Ecology* 18 :153-165).

18. Staaf H., M. Johnson and L.G. Olsen (1987). Buried germinable seeds in mature beach forests with different herbaceous Vegetation and soil types, *Holarctic Ecology* 10: 268-277.

19. Smyth A.J, F.R. Montgomery, (1962). Soil and Land use in central Western Nigeria. The Government of Western Nigeria, Ibadan.

20. Sorenson T. (1948): A method of establishing groups of equal amplitude in a Plant society based on similarity of species content. *K. Danske Vidensk Selsk* 5: 1-34.

21. Thompson, K. and Grime, J. P. (1979): Seasonal Variation in the seedbank of herbaceous species in ten contrasting habitat. *Journal of Ecology* 67: 893- 921.