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EFFECT OF WILDFIRE ON WEED FLORISTIC COMPOSITION AND SOIL STATUS IN A TEAK (*TECTONIA GRANDIS* L.) PLANTATION AT ILORIN, NIGERIA

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ABSTRACT

Teak is widely planted for timber in the tropics, grown in botanical gardens as an ornamental for its large leaves and spreading flower clusters. The study was conducted on a Teak Plantation established in phases between 2008 and 2012 to examine the impact of wildfire on weed seedling emergence and soil nutrients at Ilorin within the southern Guinea savanna of Nigeria. Soil samples were collected within three depths (0-10 cm, 11-20 cm and 21-30 cm) few days after the plantation was burnt by uncontrolled wildfire in 2016 and 2017. The weed seeds present were enumerated and soil properties analysed. Floristic weed survey was conducted on the teak plantation between May and November of each year. Results showed that *Andropogon gayanus* (18%), *Tephrosia pedicellata* (17%) and *Senna obtusifolia* (11%) were the most abundant weed species. Wildfire significantly ($p<0.05$) influenced weeds emergence. Twenty–five weed species were identified during the floristic weed survey. Twenty-two (22) % and 14 % of the identified weed species emerged on the burnt and unburnt field, respectively. Silt decreases while sand and clay fractions increased in the burn fields. Total N, organic C and available P increased in alternate years and depth of soil sampling. This result is valuable in aiding the prediction of likely weed infestations in a wildfire affected field, provide a valuable input in determining weed control strategy and soil nutrient management.

Keywords: Floristic survey, burning, bushfire, weed emergence, seed bank, soil properties

INTRODUCTION

Teak (*Tectona grandis* L.) is one of the most important timbers in the world - a rare combination of superior physical and mechanical properties makes it a paragon of timber (Anonymous, 2020). It is widely planted for timber in the tropics, often grown in botanical gardens and is occasionally cultivated in tropical countries as an ornamental for its large leaves and spreading flower clusters.

Bush burning and incidental burning of tree plantations is very common across Nigeria savannahs during the dry season and is often caused by hunters searching for game, herdsmen burning the dry field for grasses to flush at onset of rains and to control ticks, honey collectors generate smoke to drive away the bees and sometimes by negligence of passer-by, who leaves behind burning camp fires or throwing cigarette ends.

Bento-Goncalves et al (2012) reported that, the effect of fire on weed seed depends on seed properties and characteristics of fire such as fire intensity, rate of spread, energy release rate and residence time. Severe fire will kill weed seeds, but light to moderate fire may induce seed coat permeability by cracking seed coats and stimulating germination (Gashaw and Michelsen, 2002). Wildfire also burn soil nutrients and the soil is often impoverished with considerable changes in structure and water retention capacity. Fonseca et al (2017) posited that, fires cause changes on soil physical and chemical properties that, in turn, affect soil water permeability, rainwater intake rate, life forms support capacity and resistance to erosion and leaching processes while Ubuoh, et al (2017) concluded that, burning have both beneficial and detrimental effects on soil quality, it destroys the seed bank in the soil and ruins the organic matter layer of the soil. This study therefore seeks to evaluate the effect of wildfire on the volume of weed seed bank, population of emerged weed seedlings and soil chemical properties in a teak plantation.

MATERIALS AND METHODS

Experimental Site

University of Ilorin Teak plantation occupies about 400 ha established between 2008 and 2012 with the aim to substantially contribute to the Institution's revenue generation drive (Fig. 1). The plantation is located within Ilorin which is in the southern Guinea savanna ecological zone ($9^{o}29'$ N, $4^{o}35'$ E) of Nigeria and is 307 m above sea level.

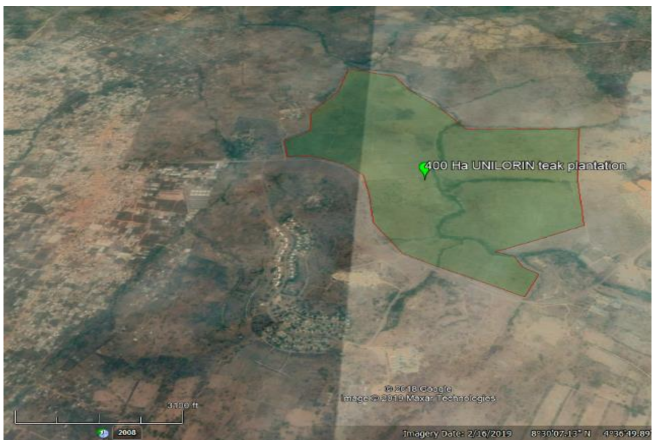

Figure 1: Imagery Image showing a 400ha Unilorin Teak Plantation

Soil Sampling

Soil samples were collected from the burnt and unburnt portions of University of Ilorin Teak Plantation using the year of establishment as a sampling factor. A total of 10 randomly selected composite soil samples were collected from 0- 10 cm, 11-20 cm and 21-30 cm depth of the soil profile. The soil cores of the same depth were bulked together, air dried and passed through a 2 mm sieve to remove non- reproducing vegetation material and stones. Two hundred grammes of the sieved soil samples were used for the determination of soil chemical properties using recommended procedures.

Seed Bank Estimation/Determination

Five hundred (500) grammes of the sieved composite soil samples were used to fill three plastic bowls (12 cm top, 9cm base diameter and 6 cm in depth) were arranged in the screen house. Each of the bowls had four perforations at the base to facilitate drainage of excess water in the soil samples. The soil samples were watered to field capacity at the beginning of the experiment and on alternate days thereafter, then monitor for weed seedling emergence at three weekly intervals for 9 months. Germinating weed seedlings were enumerated either as broadleaves, grasses or sedges, identified to species level, counted and then pulled out. Identification of weed seedlings was carried using A Handbook of West African Weeds (Akobundu *et al*., 2016). Soil samples were stirred after each assessment to stimulate germination by bringing to the surface other weeds seeds that might have been deeply buried in them. The experiment was terminated at twenty-one weeks after establishment.

Sampling of Floristic Composition

A field survey was carried out according to the quantitative survey method described by Kamal-Uddin *et al*. (2009). Quadrats of size 1m x 0.25m arranged 10 m apart in a grid pattern across transect line in each field. Each transect line were surveyed and observations were recorded from the quadrats (Takim *et al*., 2012).

Laboratory Analyses of Soil Parameters

The particle size analysis was determined using hydrometer method in 5 % sodium hexametaphosphate as the dispersing agent (Bouyoucos, 1951). The pH of the soil was determined electrometrically using a pH meter in 1:1 soil-water suspensions (Mclean, 1982). Organic matter was determined using Walkley – Black wet oxidation method (Nelson and Sommers, 1982). Total nitrogen of the soil was determined using the macro Kjeldahl method (Bremner and Mulvaney, 1982). Available phosphorus in the soil was determined using Bray P1 method (Olsen and Sommers, 1982). Exchangeable cations (Ca2+, Mg2+, K+ and Na+) were determined using 1M NH4OAc (Ammonium acetate) buffered at pH 7.0 as extractant (Thomas, 1982). The K+ and Na+ concentrations in soil extracts were read on Gallenkamp flame photometer while Ca2+ and Mg2+ concentrations in soil extracts were read using Perkin-Elmer Model 403 atomic absorption spectrophotometer (AAS).

Data Collection

Data on field weed density was enumerated at monthly intervals for five months (May-September), weed seedlings emergence from the soil seedbank was estimated for 21 weeks at 3 weeks interval while the soil chemical properties were obtained after the laboratory procedures.

Data Analysis

The number of weed seeds per land area was estimated by multiplying the number of seeds in soil sample by the inverse ratio of the volume of soil in container sample to the volume of soil in $1m^2$ area sampled to the depth of the container (Takim *et al.*, 2013) while the composition of the weed flora were analysed as in (Fadayomi and Takim, 2009). The data collected during the floristic assessment and laboratory analyses were transformed and the means were subjected to analysis of variance (ANOVA) using Genstat Discovery Edition 3 and where F-ratios were significant, the means were separated at $P \leq 0.05$.

RESULTS AND DISCUSSION

Weed Species Composition

A total of 25 weed species belonging to 23 genera and 9 families were enumerated on the experimental site (Table 1). Forty-four (44) % of all the weed species enumerated belonged to the Poaceae (11), Fabaceae (4) and Cyperaceae (3). Grasses and broadleaved species were 44% each while sedges made up of 12% of the total weed spectrum. Three weed species (*Andropogon gayanus*, *Tephrosia pedicellata* and *Senna obtusifolia*) were the most prevalent and had total field relative density of 45.65% and 61.66% relative emergence from soil sample across the soil depth. Weed seedling composition was similar across the three sugarcane fields. The relative proportion of weed species showed that about 44 % of the encountered weeds were members of Poaceae family, Fabaceae (16%) and Cyperaceae was 12 %. The result showed that, grass weed seedlings dominated the teak weed community while broadleaves had higher diversity in species (Ndarubu and Fadayomi, 2006).

Table1: Weed species composition of Unilorin Teak plantation after burnt by wildfire

Family	Weed species	%FRO	%FRD	%SRO	%SRE
Amaranthaceae	*Gomphrena celosioides* C.Mart	0.86	0.37	0.78	0.37
	Pupalia lappacea (Linn.) Juss.	2.16	1.30	2.11	1.01
Cypearaceae	*Cyperus esculentus Linn.*	3.45	2.04	3.99	1.96
	Mariscus flabelliformis Kunth var.	2.16	1.30	1.66	0.80
	Scleria verrucosa Willd	2.16	3.53	2.33	2.39
Euphorbiaceae	*Phyllanthus amarus* Schum. &Thonn.	5.60	5.75	4.55	3.29
Fabaceae	*Crotalaria retusa* Linn.	4.74	6.31	2.22	1.22
	Senna obtusifolia (L.) Irwin &Barneby	8.62	10.58	10.20	11.03
	Tephrosia bracteolate Guill & Perr	1.72	1.48	1.11	0.85
	T. pedicellata Baker	13.79	17.07	16.96	26.30
Loganiaceae	*Spigelia anthelmia* Linn.	3.88	3.71	3.22	2.17
Onagraceae	*Ludwigia octovalvis* (Jacq.) P. Raven	1.72	2.97	1.88	2.01
Poaceae	*Axonopus compressus* (Sw.) P. Beauv.	1.72	0.93	1.77	2.06
	Andropogon gayanus Kunthvar.	15.95	18.00	17.18	24.60
	A. tectorum Schum. &Thonn.	4.74	3.90	6.87	4.03
	Acroceras zizanioides Dandy	4.31	2.41	3.10	1.59
	Brachiaria deflexa (Schumach) C.E Hubbard ex Robyns	7.33	6.68	8.65	7.05
	Cynodon dactylon (L.) Pers.	0.43	0.19	0.55	0.27
	Digitaria horizontalis Willd	2.16	2.04	1.88	1.06
	Eragrostis tenella (Linn.) P. Beauv. ex. Roein & Schult	1.29	1.11	2.11	1.11
	Oryza barthii A. Chev.	2.59	1.30	1.44	0.74
	Panicum maximum Jacq	2.16	1.30	1.44	0.80
	Paspalum scrobiculatum Kunth	1.72	2.04	1.88	1.48
Rubiaceae	*Oldenlandia corymbosa* Linn	1.72	1.30	0.78	0.48
Urticaceae	*Laportea aestuans* (L.) Chew	3.02	2.41	1.33	1.27

MG= morphological group, LC=Lifecycle, FRO= Field weed relative occurrence, FRD= Field weed relative density, SRO= Seedbank weed relative occurrence, SRE=Seedbank weed relative emergence

Wildfire significantly ($P<0.05$) influenced the emergence of weed seedlings in all the assessment periods except at 3 and 4 months after burning (Table 2). At 1 MAB, the unburnt (control) field, plots established in 2008 and 2010 had significantly lower weed population compared to other plots. Similarly, 2008 established plot had significantly lower emergence weed seeds compared to other burned plots at 2MAB. While unburnt plots and other plots except 2008 and 2012 established plots had similar emerged weed seeds at 5 MAB. Cumulative weed population enumerated shows that unburnt teak plot had significantly lower weed population. The pattern of weed seedlings emergence shows that weeds emergence increases from 1MAB to peak at 3 MAB and gradually declined except in the unburnt plots where peak was observed at 2 MAB and declined sharply.

Table 2: Effect of wildfire on weed population in a Teak plantation

	Weed population (number of seedlings/m^2)					
Year of Establishment of Teak	**1MAB**	**2MAB**	**3MAB**	**4MAB**	**5MAB**	**Cumulative**
2008 Burnt	24	28	92	84	88	318
2009 Burnt	88	108	88	104	24	414
2010 Burnt	40	88	146	96	40	412
2011 Burnt	56	104	148	104	48	462
2012 Burnt	48	103	148	112	61	473
Unburnt	22	69	23	28	19	164
LSD (0.05)	23.38	53.33	NS	NS	38.76	98.58

MAB=months after burning

The impact of wildfire across year of teak establishment significantly affected the emergence of weed seeds from soil samples in all the periods of assessment (Table 3). The total emerged weed seedling was significantly lower in soil samples taken from 2008 established teak field (918 seedlings/m^2) which was similar to 1110 and 1155 seedlings/m^2 estimated from 2009 and unburnt teak field, respectively. The 2012 established teak field had significantly high number (2958 seedlings/m^2) of weed seedlings, followed by 2011 and 2010 teak fields. Similarly, impact of wildfire on weed seed emergence across soil sampling depth was significant at the first 6 weeks after establishment. The total number emerged weed seedlings showed that, high weed seeds (1922 seedlings/m^2) emerged from 11-20 cm soil depth similar to 1803 seedlings/m^2 estimated from the upper soil layer (0-10 cm soil depth) while significantly lower number of weed seeds (1556 seedlings/m^2) emerged from the 21-30 cm soil depth. The soil seedbank density decreased with the increases in soil depth. An equal distribution of weed seeds in the 11-20 cm and 21-30 cm soil depths were also observed and this support work done earlier by Mavungahidze *et al*. (2009).

Table 3: Effect of wildfire and soil sampling depth on weed seed emergence

	Weed seed emergence (number of seedling/m^2)							
	3WAE	**6WAE**	**9WAE**	**12WAE**	**15WAE**	**18WAE**	**21WAE**	**Cumulative**
Year of Establishment of Teak								
2008 Burnt	160	167	154	154	122	116	45	918
2009 Burnt	225	192	192	212	135	103	51	1110
2010 Burnt	314	385	366	353	340	231	122	2111
2011 Burnt	379	449	385	372	334	257	135	2310
2012 Burnt	507	545	552	475	456	308	116	2958
Unburnt	160	199	192	180	205	141	77	1155
LSD (0.05)	44.40	49.50	37.40	38.50	36.70	40.40	32.95	193.71
Soil Sampling Depth								
0-10cm	263	314	324	314	257	212	119	1803
11-20cm	343	388	334	289	282	196	90	1922
21-30cm	266	266	263	270	257	170	64	1556
LSD (0.05)	31.40	35.00	26.40	27.20	25.90	28.50	23.30	137.00
Interaction								
Year x Depth	NS	NS	NS	NS	*	*	NS	NS

WAE = weeks after establishment of trial

Soil Properties

Soil reaction of the teak plantation for the burnt plots over the period of 2008 to 2011 studied was not significantly different from the control (6.35). The increased mean pH values recorded in 2008 (6.48) and 2010 (6.50) could be attributed to ashes released during burning (Table 4). Ashes serves as liming and fertilizing material thereby reducing soil acidity (Adeyolanu *et al.*, 2013). Also burn-related fields increase in soil pH due to the acid neutralizing capacity of ash (Khanna *et al*., 1994) and the consumption of hydrogen ion during the combustion of organic acids in soil and forest floor, thus increases in pH values over years. The decrease in mean pH values observed in 2009 (6.17) and 2011 (6.33) could be due to the production of potassium, sodium and carbonates (Arocena and Opio, 2003), as well as the affinity of calcium, ions for phosphorous, thus, the precipitation of calcium phosphate minerals during the fractionation procedure (Giardina *et al.*, 2000).

Soil organic matter (OM) ranged between the mean values of 1.66-2.29 g kg^{-1} with control (unburnt) plot recording the highest value based on year of establishment. However, the OM content increased with depth. This increase in OM with depth corroborates with the findings of Neill *et al.* (2007) in which frequent fire reduced the thickness of the organic layer of the soil profile.

Mean value of total nitrogen (TN) was between 0.47-0.89% and 0.50-0.81% with year of establishment and depth, respectively. Availability of TN at lower depth could be attributed to leaching. Giardina *et al.* (2000) opined that soil nitrogen is sensitive to biological transformation as well as losses due to leaching, volatilization, oxidation and de-nitrification.

P was highest in unburnt than burnt plots. Available P at the 11-20 cm (5.85) increased and was higher than 0-10 cm (5.79) and 21-30 cm (5.54) depths. Heat- induced microbial mortality might have been the primary factor leading to the increase in available P (Giardina *et al.*, 2000). Available P, exchangeable Ca and K increased due to degradation of soil organic matter which was promoted by the intensity and duration of the burning. Total P and bases in ash will gradually be incorporated into the soil through percolation of rain and management practices during the year preceding the bush-fire burning (Fonseca *et al*., 2017).

Mean particle size values of sand, silt, clay of the burnt area recorded 79.60 g/kg, 7.83g/kg and 13.33 g/kg while that of the unburnt field recorded 75.85 g/kg, 9.33g/kg and 11.81g/kg, respectively . The decrease of silt in the burn plot was probably due to high temperature fussing the silt fractions hence reduction (Kattering *et al*, 2000; Ubuoh,*et al* 2017). Also there was an increased in the sand fraction of burn area due to an increase in temperature that lead to the breaking of the soil particles causing the soil to be coarse (Ubuoh,*et al* 2017) while the increased in the clay content of the burn field was due to fire severity that leads to the fusion of clay fractions in the soil as reported by Ulery *et*

Table 4: Influence of wildfire on soil properties of a Teak Plantation

	P^H (H_2O)	Total N	Org. M	P	Na	K	Ca	Mg	Sand	Silt	Clay
		gkg^{-1}			cmolkg^{-1}					gkg^{-1}	
Year of Establishment (YE)											
2008 Burnt	6.48	0.63	2.15	5.62	3.96	1.82	0.63	2.54	80.52	6.67	12.81
2009 Burnt	6.17	0.47	1.92	5.42	4.03	1.81	0.68	2.66	78.52	8.33	14.87
2010 Burnt	6.50	0.74	2.02	6.10	3.48	1.82	0.53	2.73	79.52	8.00	12.48
2011 Burnt	6.33	0.55	1.66	5.28	4.13	1.95	0.60	2.74	79.85	8.33	13.15
Unburnt	6.35	0.89	2.29	6.21	4.50	1.60	0.50	2.21	75.85	9.33	11.81
LSD (0.05)	NS	0.17	0.57	NS	NS	0.21	NS	NS	NS	NS	NS
Soil Depth (SD)											
0-10cm	6.24	0.50	1.86	5.79	3.99	1.85	0.59	2.67	83.72	8.40	7.88
11-20cm	6.51	0.65	2.04	5.85	3.97	1.76	0.58	2.56	79.92	7.00	13.11
21-30cm	6.35	0.81	2.12	5.54	4.31	1.72	0.60	2.45	72.92	9.00	18.08
LSD (0.05)	NS	0.28	0.13	NS	NS	NS	NS	NS	7.14	NS	3.95
Interaction											
YE x SD	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

CONCLUSION

The study demonstrated that wildfire significantly ($p<0.05$) influenced weed emergence and number of weed seeds decrease with an increased in soil depth. *Andropogon gayanus, Tephrosia pedicellata* and *Senna obtusifolia* were the most abundant weed species in University of Ilorin Teak Plantation. Wildfire had no significant effect on most of soil. However, total N, available P and organic C pool increased in alternate years. It could therefore be inferred that the overall effects of burning on the soil chemistry were minimal.

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