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DIVERSITY OF REGENERATING TREE SPECIES IN RESPONSE TO DIFFERENT SOIL CHEMICAL PROPERTIES IN PARKLAND AREA OF GWARZO LOCAL GOVERNMENT, KANO STATE

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ABSTRACT
This research covered the parkland of Gwarzo, along Kano road and was aimed at determining the composition and density of regenerating tree species and the diversity in terms of richness and evenness. The chemical properties of the soil were also determined. The findings of the research showed that, within the 50 systematically sampled plots of 25x25m, a total of 920 regenerating stems were encountered belonging to 16 different species, distributed within 11 families. Family *Fabacaceae* had the highest number of four (4) species, followed by *Anacardiaceae* and *Combretaceae* with two (2) species each. Families *Bombacaceae*, *Moraceae, Maliaceae*, *Ebanaceae*, *Vertenaceae*, *Rhamnaceae*, *Myrtaceae* and *Zygophyllaceae* had one (1) species each. Poor regeneration was reported as the number of seedlings was very low compared to the saplings and trees. *Diospyros mespiliformis*, *Eucalyptus camaldulensis*, *Azadirachta indica*, and *Parkia biglobosa* showed a high regeneration potential. Fewer seedling and and saplings were recorded for *Terminalia macroptera, Ficus sycomorus and Anogeissus leiocarpus*. The Shannon wiener diversity index value (H') is moderate for all the classes; Seedlings (2.0572), Saplings (2.4394) and Trees (2.6502). Soil organic matter, available phosphorous, total Nitrogen, K, Mg, and Na decrease with increasing depth.

INTRODUCTION

The pressure of growing populations in developing countries has forced land less farmers un to soils which cannot sustain crop production and slopes that cannot be cultivated safely Food and Agriculture Organization (1997). Most subsistence farmers in semi-arid West Africa consider trees and shrubs as an integral part of agriculture, and for centuries they have maintained a traditional land-use system known as the parkland Agroforestry system. Due to their multiple uses, parkland tree and shrub species play an important role in socio-economic development and in preserving ecological equilibrium. In addition to food and medicinal products, they supply farmers with wood for energy and construction, fibers for roofing, and fodder for livestock. These products are also sources of additional revenue for farmers in West Africa. Although their contribution to farmers' livelihood improvement is widely appreciated, it has rarely been quantified (Faye, Weber, Mounkoro and Dakouo, 2010). The agricultural production system of this region is influenced by many problems relating to climate change, natural resources degradation, endemic pests and diseases, price fluctuations and changing government policies(Manjunath, 2018). Increasing demand for land has also intensified deforestation; the traditional system of Agriculture is largely characterized by clearance of vegetation (Okonkwo, 2010). Tree regeneration is described as the act of renewing tree cover by establishing young trees naturally or artificially, after the previous stand or forest has been removed. The method, species and density are chosen to meet the goal of the landowner. Regeneration of trees can be natural through coppicing, self-sown seeds and root suckers or artificial by (planting chosen species, (Sarkar and Devi, 2014). According to Bonkoungouet *et al*. (1994), farmed parklands "are land-use systems in which woody perennials are deliberately preserved in association with crops and/or animals in a spatially dispersed arrangement and where there is both ecological and economic interaction between the trees and other components of the system". Nair (1985) stated that, In the ICRAF Agroforestry systems inventory; farmed parklands are included in the category of 'multipurpose trees on farmlands'. The term 'farmed parkland' also encompass parklands being farmed as well as land lying fallow, and does not exclude a pastoralist component. Farmed parklands are common types of Agroforestry systems in the tropics that were over looked for a long time (FAO, 1997). Studies by Gideon and Verunumbe (2013) observed that trees feature prominently in traditional farming system because of their contributions to famers' livelihood. The use of trees through planting or Farmer Managed Natural Regeneration (FMNR) in cropland can be achieved at a lower cost, making it more practical, for soil fertility management and improvement in this context(Neya *et al*., 2020), Trees are also known to act as biological pumps that can transpire copious amount of soil water into the atmosphere(Sukham madan , 2018). Tree regeneration is a central component for tropical forest ecosystem dynamics and is essential for preservation and maintenance of biodiversity (Rahman *et al*., 2011). The objective of the research was to assess the diversity of regenerating tree species in relation to some soil chemical properties in the area.

MATERIALS AND METHODS

Study Area

The study was carried out in Gwarzo local government area of Kano state, Nigeria, located between latitude 11º23′26" and 11º58′11"N and longitude 7º15011 and 8º1115911E, with a population estimate of 216,570 people and a total area of 393km2 (NPC, 2006). The area has a mean annual rainfall of about 696.4mm that last usually for three to five months, the mean temperature ranges from 260C to 33ºC.The area is characterized by four distinct seasons (KNSG, 2014).

Data Collection

Sampled plots were marked using plastic rope and four wooden pegs within the plots, all types of regenerated tree species encountered were identified, counted and measured. Individual trees having dbh of ≥ 30cm diameter (measured at breast height) was considered as Trees, saplings with ≥ 10cm to < 30cm diameter and seedlings with < 10cm diameter. The status of regeneration of species was determined based on population size of seedlings, saplings and trees as modified by Shankar (2001) and Khumbongmayum *et al*. (2006). Soil samples were also collected for chemical analysis. Explain how the soil samples were collected.

Sampling Procedure

A systematic sampling technique of parallel line transect with plots method was employed Getachew and Biruk (2014) , Fifty (50) 25×25m plots were set up and spaced at interval of 100m along linear transects separated by 200m from one another, and all the tree species encountered within the plots were identified, and measured. All sample plots were located at least 100m from the road to avoid edge effect.

Vegetation Analysis

The data obtained from the study were presented in tables; species richness, diversity and evenness of regenerating tree species were analyzed using biodiversity formulas and methods adapted from (Abasse *et al*., 2011; Bayala *et al*., 2015; BOLANLE-OJO, FALANA, BOLANLE-OJO, & LEVAN, 2020; Maikhuri and Dhyani, 2020; Dyderski & Jagodziñski, 2020) as follows:

Shannon's diversity index:

Where H′ = Shannon diversity and Pi = proportion of individual species. ln = natural logarithm.

$$H = -\sum Pi \ln Pi \text{......... ....} (1)$$

Species richness is an index based on the number of species; it describes Variety of species or the number of different species (or genera, families, *etc*.).

Species richness R is given as

$$d = N\sqrt{S} \text{ ....} (2)$$

Where; S is number of species; N is number of individuals. Evenness is a measure of the relative abundance of the different species making up the richness of an area.

Evenness is calculated using Shannon Evenness index (E′)

$$E' = H2/H2\ max \text{ or } E' = H'/\ln S \text{.........................} (3)$$

Where, H′ is observed diversity;

H2 max is equal to natural logarithm of richness, ln S.

Density = total No of stems of the species/ sampled area (ha) .... (4)

Soil Sampling and Collection

Composite soil samples were collected from the plots sampled at a depth of 0-15cm and 15-30cm close to the seedlings, saplings and tree species using soil auger. The soil samples collected were air dried, crushed gently and sieved through 2mm mesh for laboratory analysis (LILONGCHEM THYUG AND KAKATI, 2018).

Determination of Soil Chemical Properties

Soil pH was determined using electrode pH meter in 1:1 soil-water solution.

Following Walkey and Black (1934), soil organic carbon was obtained and then multiplied by 1.729 to estimate organic matter content.

Determination of available P was achieved by electro-photometer method of Bray and Kurt, 1945, exchangeable K and Na by digital flame photometry, exchangeable Ca and Mg were determined using EDTA, while total N was determined using macro-kjeldal method with selenium catalyst.

Cation exchange capacity (CEC) was determined by saturating the soil samples with normal neutral ammonium acetate solution, washing excess with alcohol, distilled and titrated against standard hydrochloric acid following Lavkulich,(1981 method

Soil Analysis

Data from laboratory analysis of the soil were subjected to analysis of variance (ANOVA) using SPSS and where significant difference existed, Tukey's HSD Test was used to separate the mean.

RESULTS AND DISCUSSION

Species Diversity Index

Values followed by different superscripts along the rows indicate significant difference Soil chemical properties.

Diversity Index

Depending on the available tree species in an ecological zone, the diversity indices varies with location, the parklands of Gwarzo, is blessed with moderate diversity of regenerating tree species, in which Trees had higher diversity of 2.6502, followed by saplings (2.4394) and seedlings had the least diversity with 2.0572, this falls within the general limits of 1.5-3.5 (Kent and Coker, 1992). In comparison, the result agreed with the findings of Bello *et al*. (2013) in which they recorded a diversity value of 2.626 for trees at Kogo forest reserve, but higher than what Dikko (2012) found at Dabagi, who recorded H′ value of 1.45 for trees which is very low. Other findings by Onyekwelu *et al*. (2007) recorded H′ values of 3.12 and 3.31 at Oluwa and Queen's Forests, south-western Nigeria. The moderate diversity obtained at the parkland of Gwarzo showed that climate favors diversity and may be partly responsible for

Table 1: Checklist of tree species and Shannon diversity value (H1) for seedlings

Species	Ni	Pi	InPi	(Pi)(InPi)
Adansonia digitata	13	0.094	-2.3645	0.2223
Azadirachta indica	23	0.167	-1.7898	0.2989
Terminalia macroptera	0	0.000	0.0000	0.0000
Ficus sycomorus	0	0.000	0.0000	0.0000
Parkia biglobosa	11	0.080	-2.5257	0.2021
Faidherbia albida	0	0.0000	0.0000	0.0000
Diaspyros mespiliformis	27	0.196	-1.6296	0.3194
Tamarindus indica	9	0.065	-2.7334	0.1777
Balanites aegyptiaca	0	0000	00000	0.0000
Mangifera indica	16	0.116	-2.1542	0.2413
Vitex doniana	0	0.000	0.0000	0.0000
Anogeissus leiocarpus	0	0.000	0.0000	0.0000
Sclerocarya birrea	0	0.000	0.0000	0.0000
Ziziphus spina-christi	11	0.080	-2.5257	0.2021
Eucalyptus camaldulensis	25	0.181	-1.7073	0.3094
Daniellia olivieri	3	0.022	-3.8167	0.0840

Source: Field Survey, 2015

Table 2: Shannon's diversity value (H') for saplings

Species	Ni	Pi	InPi	- (Pi) x (InPi)
Adansonia digitata	19	0.077	-2.5639	0.1974
Azadirachta indica	31	0.126	-2.0715	0.2610
Terminalia macroptera	0	0.000	0.000	0.0000
Ficus sycomorus	0	0.000	0.0000	0.000
Parkia biglobosa	27	0.110	-2.2073	0.2428
Faidherbia albida	9	0.037	-3.2968	0.1220
Diaspyros mespiliformis	33	0.134	-2.0099	0.2693
Tamarindus indica	21	0.085	-2.4665	0.2097
Balanites aegyptiaca	17	0.069	-2.6736	0.1845
Mangifera indica	20	0.081	-2.5133	0.2036
Vitex doniana	11	0.045	-3.5756	0.1395
Anogeissus leiocarpus	7	0.028	-3.5756	0.1001
Sclerocarya birrea	0	0.000	0.0000	0.0000
Ziziphus spina-christi	18	0.073	-2.6173	0.1911
Eucalyptus camaldulensis	29	0.118	-2.1371	0.2522
Daniellia olivieri	4	0.016	-4.1352	0.0662

Source: Field Survey, 2015

Table 3 : Species richness (R), evenness (E) and density values

Diversity indices	Seedlings	saplings	Trees
Species richness	1.3620	1.0201	0.6912
Species evenness	0.7420	0.8798	0.9559
Density (per hectare)	44.16	78.72	171.52

Source: Field Survey, 2015

the diversity obtained in the area; this also confirmed that ecological factors dictate the distribution and abundance of species.

Margurran (1988), described Evenness (EH) as a measure of Equitability of spread of available species. The regenerating species had a calculated evenness of 0.742, 0.879 and 0.9559 for seedlings, saplings and trees respectively, which are higher than Kuwanka Banza Forest reserve (0.74) as recorded by Danjibo (2014), Dabagi (0.74) as recorded by Dikko (2012). This indicate that all the regeneration indicators are moderately distributed in the parklands, which may be due to less competition for space among the tree species considering the nature of the site. In a similar research conducted by Nuraddeen (2014) at the parklands of Katsina state, the species richness stood at 0.73 to 1.56. The differences may be as a result of the more favorable conditions of the tropical rainforest zone in comparison to the Sudan savanna zone, level of exploitation, adaptability of species, and preference by the exploiters.

Soil Chemical Properties

The pH of the soil indicated alkaline conditions (8.03 to 8.25) which were not different; this may be due to the homogeneity in the parent material of the parkland. Soil pH influences nutrient uptake, hence tree growth, Londo and Carta (2002) argued that a pH of 6.5-7.0 generally provide the best growing conditions and may partly be responsible for the ability of an area to fairly sustain a reasonable number of species, despite constrains of efficient management practices. The poor regeneration recorded in the parkland may therefore be linked to the alkaline nature of the soil.

Organic matter content of the soil is low compared to 7.38 %, 11.57% and 8.42% recorded respectively at Jimajimi, Yartagimba and Daji areas as reported by Muhammad (2010), this may be due to the lower microbial counts that could undertake litter decomposition, lower litter falls or low moisture content that will enhance microbial activities. The organic matter of the soil was also low compared to what Bishir (2012) found at Kogo Forest Reserve in North West Nigeria.. Organic matter affects tree growth through its effect on the physical, chemical and biological properties of the soil (Iwara 2009),

Table 4: Soil chemical properties

	Seedlings	Saplings	Tree	F	Sig
Ph	8.06 ± 0.75	8.07 ± 0.13	8.16 ± 0.74	2.33	0.13
O.M (g/kg)	3.88 ± 1.8^{a}	3.51 ± 0.27^{b}	3.80 ± 0.18^{ab}	4.95	0.02
CEC	31.16 ± 0.89	24.78 ± 0.79	30.34 ± 0.62	1.58	0.24
N (g/kg)	0.06 ± 0.05	0.06 ± 0.04	0.17 ± 0.24	1.21	0.33
P (mg/kg)	0.87 ± 0.05^{a}	0.81 ± 0.03^{b}	0.94 ± 0.02^{c}	42.16	0
K (cmol/kg)	0.06 ± 0.03^{a}	0.05 ± 0.06^{a}	0.04 ± 0.08^{ab}	9.27	0.02
Na (cmol/kg)	2.99 ± 0.11^{a}	2.49 ± 0.23^{b}	2.53 ± 0.26^{b}	8.9	0.02
Ca (cmol/kg)	0.55 ± 0.07	0.46 ± 0.23	0.50 ± 0.13	0.4	0.67
Mg (cmol/kg)	1.21 ± 0.88^{a}	1.09 ± 0.06	1.34 ± 1.07^{b}	11.89	0.01

Values followed by different superscripts along the rows indicate significant difference Soil chemical properties

this may be responsible for the poor regeneration recorded in the area. Total available Nitrogen recorded in the area was very low compared to what Halil *et al*. (2010) recorded at the Oriental Beech Forests in Turkey, lower than what Bishir (2012) obtained at Kogo, and also less than that of Kumar *et al*. (2010), this shows that the result is not within the range for the agro ecological zone. Phosphorous, this occurred in phosphate form, decreased with increase in depth, were lower than that reported by of Bhat and Kareriappa (2009), Bishir (2012) and Muhammad (2010) who recorded 1.26, 18- 2.27, and 2.41-6.35 respectively.

The influence of soil properties on the distribution of flora have been documented by scholars in the past. Aweto and Dikinya (2003) identified organic matter and clay proportion as soil variables that exerted marked influence on the distribution and abundance of tree species.; Ukpong (1994) identified nutrient and salinity as factors explaining species variation in mangrove swamps; John *et al*. (2007) identified soil pH as the strongest soil factor that influenced the distribution of species in three tropical forest; Udoh *et al*. (2007) identified Mn, clay content and TN as soil factors that influenced species distribution; Zare *et al*. (2011) identified soil texture, salinity, effective soil depth, available nitrogen, potassium, organic matter, lime and soil moisture as major soil factors responsible for variations in the pattern of vegetation, it was also observed that Agroforestry resulted in lower soil pH, N, and total and exchangeable Ca^{2+} contents (Deng, 2020), Aparajita 2007, observed that vegetation was related to the chemistry of the surface-soil layer, including nitrate, organic carbon, C/N ratio and water content, and also the active-layer depth, while Medinski (2007) identified clay and silt,. Soil EC and pH to influence the distribution and life form abundance. These results perhaps implied that tree/shrub species were selective of nutrients as well as depended entirely on the spatial heterogeneity of soil in nutrient distribution.

In consideration of the study area (Sudan savanna) in which the trees are scattered, coupled with human disturbances in terms of overexploitation of the tree species which had already exposed the soil and of course changed the soils in terms of structure, moisture content, and possibly micro fauna and flora. Regeneration can be negatively affected by the soil in one way or the other in terms of nutrient cycling and fertility.

Significance Statement

This study discovered that, there was poor tree regeneration potential in the area as a result of poor nutrients availability in the soil which was due to high deforestation rate that expose the soil. This result can help farmers understand the right amount of fertilizer to apply for sustainable food production, and also help the policy and decision makers come up with sound laws that will encourage reforestations and discourage deforestation.

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