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Characterization of Natural Regeneration of Three Local Multipurpose Tree Species in the *Ouaddaï sahelian* Zone of Chad

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Abstract: In the Sahelian zone of Ouaddaï in Chad, *Balanites aegyptiaca* (L.), *Sclerocarya birrea* (A. Rich.) and *Ziziphus mauritiana* Lam. are multipurpose woody species that are found in agroforestry land use systems and contribute to the nutrition, health and economy of local populations. The purpose of the study is to assess the natural regeneration and population structure of these species in view to contribute to their domestication. The study was carried out in three land use systems (farms, fallows and savannahs). Regeneration characterization consist in a carefull excavation of root system of mother - tree and of regenerations to distinguish suckers from seedlings. The origin of the plant (sucker or seedling) was determined by carefully checking of the root system to see if there was a connection between the root of the regenerations and that of the mother - tree. In addition to the prudent excavation of the root system of the regenerations, their dendrometric parameters as well as those of the mother - tree were determined. Results show that populations of these species are not uniformly distributed in land use systems of the area. The mean density of the trees varied significantly between species (0.000<0.001) as well as in land use systems (0.000<0.001). Trees of wide diameter are significantly more abundant in farms than in savannahs (0.000<0.001). Among the 10151 juvenile trees recorded in plots, 59.58% are reiterations; 33.62% seedlings while 6.79% are suckers. *S. birrea* presented the highest natural suckering percentage. *S. birrea* shows a highest suckering percentage in the three land use systems while the lowest was that of *B. aegyptiaca*. The highest natural root suckering percentage is registered in fallows (7.14% in *B. aegyptiaca*, 12.57% in *Z. mauritiana* and 14.77% in *S. birrea*). The ecological conditions favourable to natural root suckering were those of farms whereas those of fallows were suitable for the growth and rooting of suckers. These results suggest the urgent needs to promote low coast vegetative propagation techniques like root suckering for the domestication of these important tree species.

Keywords: Broken Collarborne, Chad, Characterization, Multipurpose Tree, Natural Regeneration, Seedling, Stump Shoot, Root Suckering

1. Introduction

The sahelian land use systems sufer nowdays from accelerated degradation resulting from joint actions of climate change and anthropique pressures. This degradation is characterized by the diminishing of plant cover as well as the depletion of certains multipurpose tree species. Many species are threatened nowadays to extinction due to overexploitation and, above all, exploitation using non-recommended techniques [1]. The over-exploitation of species of great socio-economic importance is placing their

populations in a regressive dynamic characterised by the rarefaction or absence of juvenile individuals [2, 3]. Facing these threats, it is pressing to determine strategies liable to bend degradation trends of these ressources [4]. *Balanites aegyptiaca* (L.) Del., *Sclerocarya birrea* (A. Rich.) and *Ziziphus mauritiana* Lam. are multi-purpose woody species whose various products are sought and sold in most local and regional markets [5, 6]. Despite their great socio-economic importance in this sahelian zone of Chad, scientific data based on their structure, population status and natural regeneration are still limited. The purpose of the present work is to characterize the population structure and the natural regeneration of these plant species in the prospect of developping a suitable domestication programme for their conservation and management.

2. Materials and Methods

2.1. Study Site

The work was undertaken in the sahelian zone of Chad precisely in the region of Ouaddaï. It is situated in the chadian sahel located between 13°39'N and 21°44'E. The climate of Ouaddaï is a warm tropical type with 300 and 600 mm/year. It is characterized by 02 distinct seasons. A long dry season from October to June and a short rainy one from July to September. During years of good rainfalls, precipitations oscillate between 500 and 600mm whereas in years of deficitairies, they oscillate between 100 and 150 mm /year. The vegetation of the zone is of sahelian steppique where many plant formations according to the nature of soil, topography and depth of the phreatic layer [7]. This vegetation moves following the gradient north - south, grass steppe, low shrub to thorny often very scattered to arboreous and clear forests or little dense to average tick in the south. The population is composed in majoritary by farmers (Maba) and cattle-breeders (Arabs).

2.2. Methods

2.2.1. Species Chosen

The choice of the species *Balanites aegyptiaca* (Zygophyllaceae), *Sclerocarya birrea* (Anacardiaceae) and *Ziziphus mauritiana* (Rhamnaceae) was motivated by their socio-economical importance in addition to the decline of their population due to repeated drought in the region. The other justification is the use of incovenient practices for their management and the farmers' lack of knowledges on simple and inexpensive vegetative propagation technique.

2.2.2. Natural Regeneration Characterisation

The aim of this work is to assess the aptitude of natural root suckering and the state of regeneration of each of the three species studied. They were undertaken in three land use systems such as farms, fallows and savannahs. In each land use systems, 30 plots of 100 x 100 m^2 distant of 80 m were delimited [2]. Each plot was split up into sub-plot of 50 x 20 m. In total, 270 sub-plots per species and per land use system were delimited. Inside each plot and around each species, all the regenations were located and identified. A tree or the stump shoot, the most developped of a stool is considered as a regeneration when its diameter is less than 3 cm and / or its maximal height is 2 m [8]. The regeneration include all the plants for which the diameter of the stem is less than 3 cm and the height less than 2 m. The stool with at least one stump shoot having a diameter greater than 3cm is considered as mature. The origin of the plants (seedlings or suckers) was determined by the careful excavation of the root system of the mother - tree. The nature of the plants was determined simply by observing the roots: tap roots of small diameter for seedlings, superficial roots connected to the mother - root for suckers. Materials used for that were pickaxe, shovel, hoe, decameter, etc. The experimental design was a Split-plot with 10 replications. The main treatment was the plant species and the land use systems, the sub-treatment. In addition to prudent excavation of the root system of the regenerations root's, their dendrometric parameters (sucker emergence distance, number of rooted suckers, number of suckers/tree, diameter and height of regeneration, etc.) as well as those of the mother - tree were determined (diameter at breast height, root diameter, density, etc.). In this study, broken collarbones, stump sprouts and adventitious shoots are considered as reiterations. A distal sucker is the one which appears on the end of the root disconnected from the mother - root and proximal sucker is developped on the part of the connected root that is closest to the trunk of the mother - tree [9]. For the same authors, regeneration include vegetative propagation (reiterats, collabones) and sexual propagation (seedlings).

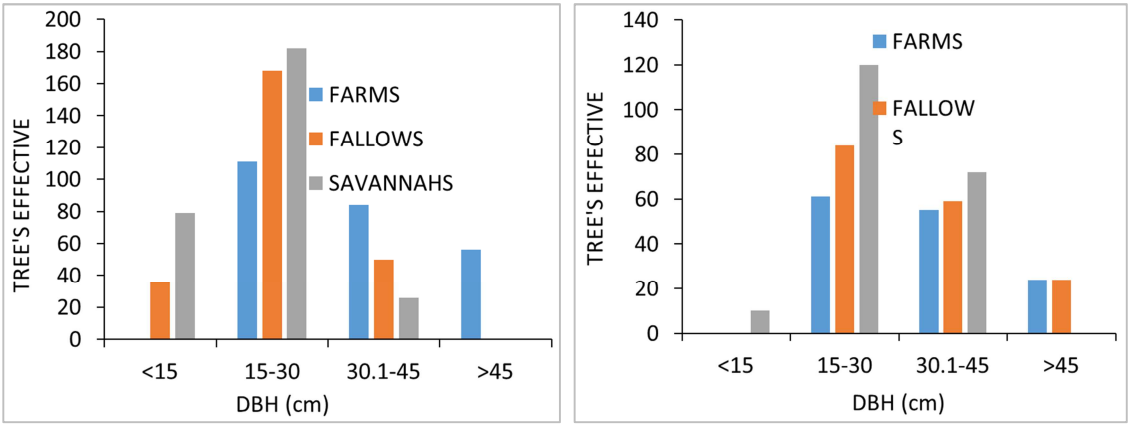
2.2.3. Data Analysis

Different dendrometric parameters of the regenerations were determined. Data collected were subjected to an analysis of variance (ANOVA). Significant means were separated by the Duncan Multiple Range Test. The statistical program used was Statgraphics plus 5.0. The Excel spreadsheet was used to draw the graphs. The program Microsoft Excel serves to classify numeric data and draw graphs.

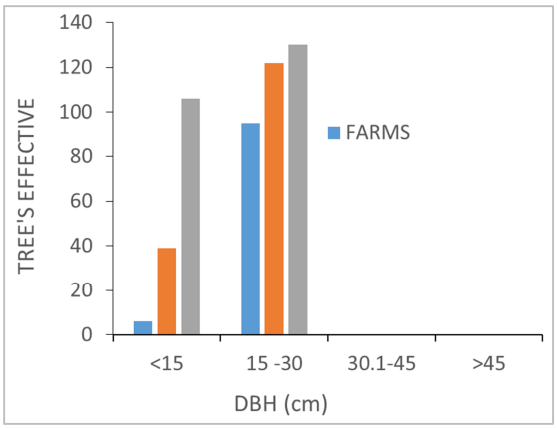
3. Results

3.1. Distribution of Tree's Population

The assessment of the population of these multipurpose tree species is based on their diameter at breast height and density. Examination of the tree population structures of the three species in the different land-use systems of the region reveals that the population growth dynamics of each species is roughly regressive, irrespective to the land use systems. Regardless of the species, the maximum number of trees is obtained in the 15-30 cm diameter class. Beyond this diameter class, there are no trees in *Ziziphus mauritiana*. The population structure of *B. aegyptiaca* and *S. birrea* follows the look of normal distribution (Figure 1).



Balanites aegyptiaca *Sclerocarya birrea*



Ziziphus mauritiana

Figure 1. *Tree's effective versus diameter in land use systems.*

Despite the pressure in savannahs, the number of trees is higher than elsewhere. In *Z. mauritiana*'s population, there is lack of mature individuals with diameter greater than 30 cm, what ever being the land use systems.

The diameter varied from 18.08±2.52 cm in *Ziziphus mauritiana* to 30.87±3.7 cm for *Sclerocarya birrea*. The mean diameter at the breast height of the trees varies significantly among the species (0.000<0.001). The variability in land use systems oscillates between 20.69±5.81 cm in the savannah and 29.82±8.97cm in the farms. Between the land use systems, there is a significant difference (0.000<0.001). Trees with large diameter are abundant in farms than elsewhere (Figure 2). The interaction between species and land use systems was also significant (0.000<0.001).

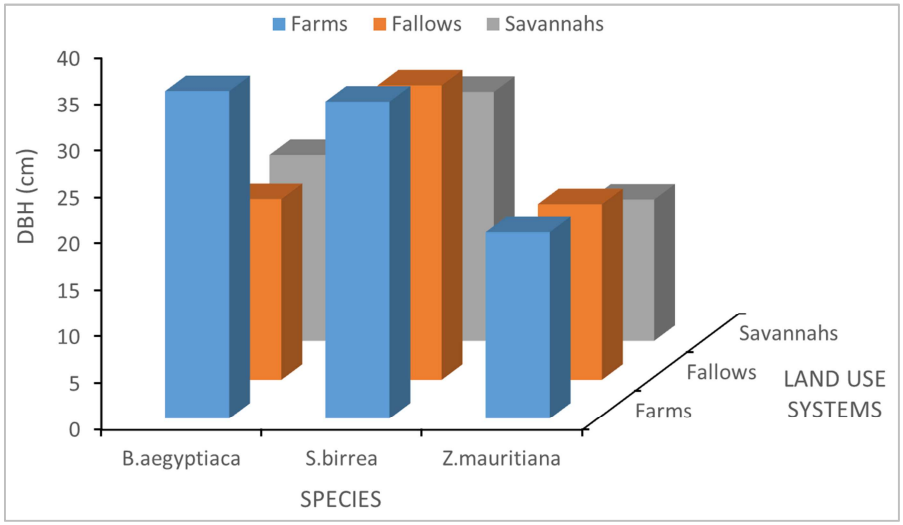


Figure 2. *Diameter of trees according to species versus land use systems.*

The mean density of species varies from 6.08±1.74 in *Z. mauritiana* to 8.76±0.81 stems.ha^{-1} in *S. birrea*. There is a significant difference between species (0.000<0.001). In land use systems, the trees density ranges from 6.18±1.74 in farms to 7.91±1.66 stems/ha in savannahs. The variability between land use systems is established because the analysis of variance indicates a significant difference among the land use systems (0.000<0.001). For the interaction species land use systems, the density varies from 5.06±1.63 in *Z. mauritiana* in the farms to 9.7±3.27 in *S. birrea* in savannahs. However, the interaction between species and land use systems was not significant (0.39>0.05).

3.2. Natural Regeneration Modes of Species

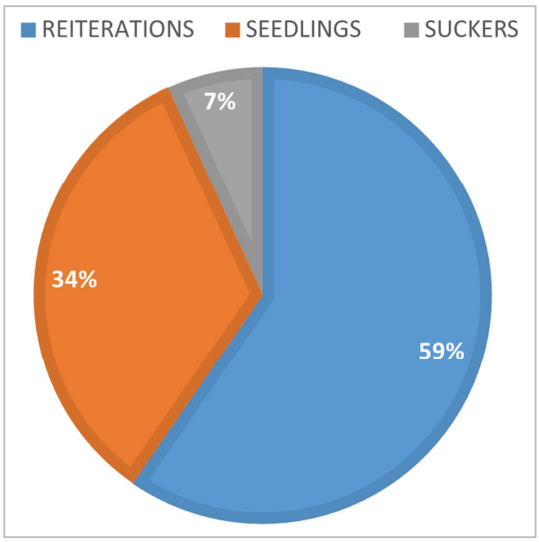


Figure 3. *Allotment of regenerations in land use systems of Ouaddaï.*

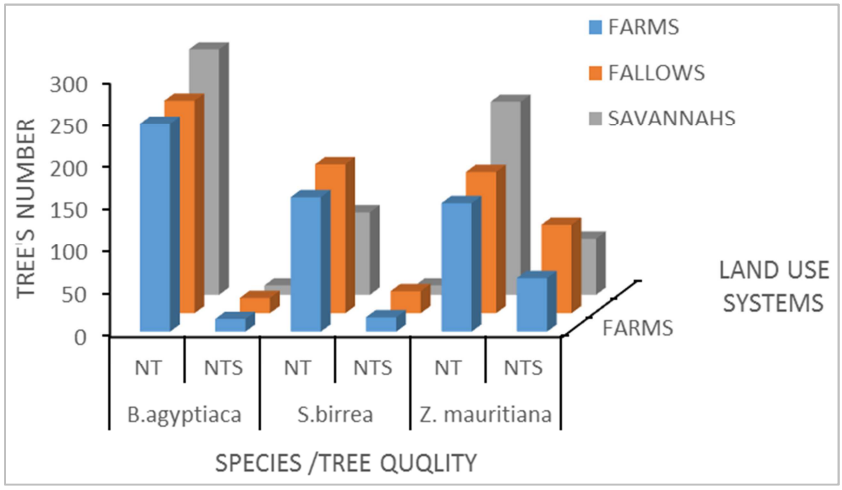
After partial excavation of root system of mother-trees, a total of 10151 juvenile stems of different ages among which, 59.58% are broken collarbornes while 33.62% were seedlings and 6.79% suckers, were recorded (Figure 3). In dry season, these regenerations were vulnerable to bushfires as well as to livestock. In sahelian area of Ouaddaï, *B. aegyptiaca*, *S. birrea* and *Z. mauritiana* show natural predispositions to regenerate by these modes of propagation (sexual, reiteration, root suckering). The high number of stump shoots are the fact of the mother - tree depletion due to regular droughts and busfires. None marcot was observed during field observations.

3.2.1. Reiteration Density

The density of the reiteration of species oscillates between 12.62 ±6.18 stems/ha in *Sclerocarya birrea* and 35.64 ± 7.68 stems/ha in *Balanites aegyptiaca*. The difference is significant among the species (0.000<0.001). In the same line, the density varies significantly from 24.98 ± 2,4 stems/ha in farms to 35.5± 13.89 stems/ha in fallows (0.000<0.001). The reiteration density fluctuates from 19.46 ± 9.44 stems/ha in *Sclerocarya birrea* in savannahs to 44.06±25.45 stems/ha in *Balanites aegyptiaca* in fallows. The interaction between species and land use systems was not significant (0.52<0.05).

3.2.2. Seedlings Density

The seedlings density of *S. birrea* presents 5.25±1.75 stems.ha^{-1} while that of *B. aegyptiaca* is 20.52± 3.05 stems.ha^{-1}. There is significant difference among the species (0.000 < 0.001). According to the land use systems, it ranges from 11.04±5.64 in farms to 14.48±1.75 stems.ha^{-1} in fallows. For the interaction species*land use systems, the seedling density fluctuates from 3.26±2.32 in *S. birrea* in the farms to 22.96±8.07 stems. ha^{-1} in *B. aegyptiaca* equally in the farms. There was also a significant difference for the species by land use systems interaction (0.002 < 0.01).



NT = number of trees, NTS = Number of trees which stool

Figure 4. *Tree's effective according species capacity to stool.*

3.2.3. Suckers

For a total of 1770 trees surveyed in the Ouaddaï land-use systems, including 789 for *B. aegyptiaca*, 433 for *S. birrea* and 548 for *Z. mauritiana*, a total of 333 suckers were

checked. Among them, 44 in *B. aegyptiaca*, 54 in *S. birrea* and 235 in *Z. mauritiana* stool suckers. The number of trees in general is higher in savannahs than other systems of production (Figure 4). The number of trees growing is also higher in savannahs than in other land-use systems. This is due to the disturbance caused by land clearing by farmers in the two other systems.

The sucker density varies from à 1.94±0.81 in *B. aegyptiaca* to 3.11±0.73 suckers.ha^{-1} in *S. birrea*. Despite the variability observed, there is not a significant difference among the species (0.21 > 0.05). The density of suckers fluctuates from 1.8±0.46 in savannahs to 3.54±0.18 suckers.ha^{-1} in the fallows. Among the land use systems, there is a significant difference (0.02 < 0.05). For the species * land use systems interaction, it ranges from 1.36±0.12 in *B. aegyptiaca* growing in the savannahs to 4.3±0.18 suckers.ha^{-1} in *S. birrea* in the fallows (Table 1). However, the interaction between species and land use systems showed no significant difference (0.88>0.05).

Table 1. *Density of suckers according species versus land use systems.*

Land use systems /Species	Farms	Fallows	Savannahs	Mean
Balanites aegptiaca	1.63 ± 0.13	2.83 ± 0.21	1.36 ± 0.12	1.94± 0.81
Sclerocarya birrea	3.23 ± 0.12	4.3 ± 0.18	1.8 ± 0.11	3.11 ± 0.73
Ziziphus mauritiana	2.1 ± 0.11	3.5 ± 0.14	2.23 ± 0.09	2.61±0.11
Mean	2.32±0.12b	3.54±0.18a	1.79±0.11bc	2,55±0.14

Means followed by different letters are significant at P < 0.05

(i). Sucker Emergence Distance

The sucker mean emergence distance varies according to species. This distance varies significantly from 56.49± 24.57cm in *Z. mauritiana* to 141.1±81.21 cm in *S. birrea* (0.000<0.001). For the land use systems, it ranges from 78.28±6.56 cm in savannahs to 102.91±65.54 cm in fallows. Despite the variation, there is not significant difference among the systems (0.32>0.05). Concerning the species *land use systems interaction, it fluctuates from 47.12±35.99 cm in *Z. mauritiana* in savannahs to 216.17±116.16 cm in *S. birrea* in the fallows. Nevertheless, for the interaction, there is also no significant difference (0.18>0.05).

(ii). Rooting Sucker

The number of suckers which rooted naturally varies from 11.77±0.95 in *B. aegyptiaca* to 30±2.08 in *Z. mauritiana* (Table 2). Concerning the land use systems, the number of rooted suckers ranges from 14.33±0.98 in farms to 42.33±2.42 in fallows (Table 2). The analysis of variance indicates significant difference among the land use systems (0.000<0.001). The interaction between species and land use systems shows that the number of rooted suckers varies from 8 ±0.58 in *B. aegyptiaca* in farms to 49±2.85 in *S. birrea* in fallow land. The total number of rooted suckers is 23.37±1.59 while that of rooting percentage is 31.70%.

Table 2. *Number of rooted suckers according to land use systems.*

Land use systems /	Farms		Fallows		Savannahs		Mean	
Species	NRS	SP (%)	NRS	SP (%)	NRS	SP (%)	NRS	SP (%)
Balanites aegyptiaca	8 ± 0.58	16.32	33 ± 1.34	38.82	11 ± 0.92	26.82	11.77±0.95	27.32
Sclerocarya birrea	16 ± 0.81	16.49	49 ± 2.85	37.98	20 ± 1.53	37.03	28.33±1.73	30.50
Ziziphus mauritiana	19 ± 1.56	30.15	45 ± 3.08	42.85	26 ± 1.59	38.8	30.00±2.08	37.27
Mean	14.33±0.98c	20.99	42.33±2.42a	39.88	19±1.35b	34.22	23.37±1.59	31.70

NRS: number of rooted suckers; SP: Suckering percentage; Means followed by different letters are significant at P < 0.05

Roots in *S. birrea* are abundant and well developped than those appearing in *Z. mauritiana* species (Figure 5).

a b

Figure 5. *Rooted suckers in Ziziphus mauritiana (a) and S. birrea (b).*

The diameter of the mother-tree which stools, varies from 0.98±0.12 cm both in *B. aegyptiaca* and *Z. maritiana* to 1.03 ± 0.16 cm in *S. Birrea* (Table 3). There is not a significant difference among the diameter of species (0.94>0.05). The diameter of mother - trees oscillates between 0.84±0.28 cm in savannahs to 1.19±0.13 cm in fallows without a significant difference (0.09>0.05). The interaction between species and land use systems does not also show a significant difference (0.25>0.05). The standard error is higher than the mean due to abundance of null values in the data.

Table 3. *Diameter of the mother - root witch produces suckers.*

Land use systems /Species	Farms	Fallows	Savannahs	Mean
Balanites aegptiaca	1.01 ± 1.09	1.09 ± 1.17	0.85 ± 1.17	0.98±1.14
Sclerocarya birrea	1.06 ± 1.13	1.34 ± 1.21	0.54 ± 0.85	0.98±1.06
Ziziphus mauritiana	0.84 ± 1.05	1.14 ± 0.97	1.11 ± 1.12	1.03±1.05
Mean	0.84 ± 1.09	1.19±1.2	0.83±1.05	0.99±1.11

3.3. Regeneration Growth of Species

The juvenile regeneration include reiterations, seedlings and suckers. Their growth refers to the height and the width.

3.3.1. Reiterations

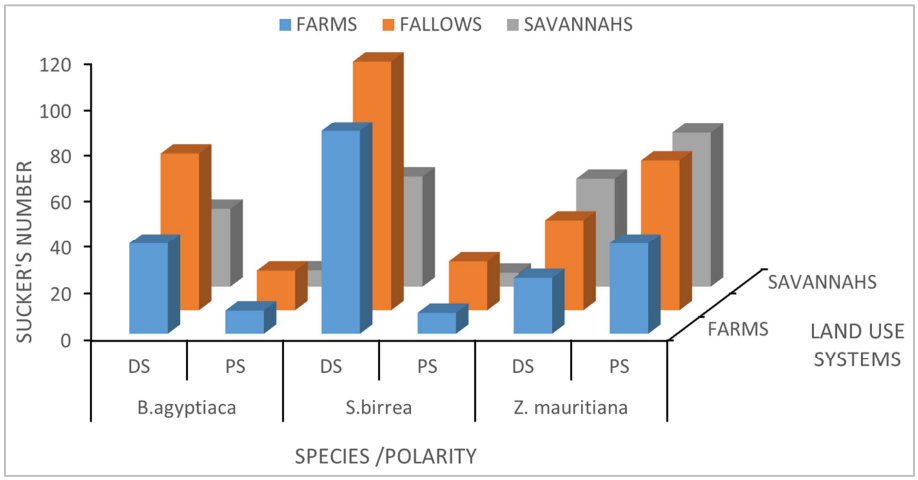
The mean height of the regenerations varies from 88.13±23.33 cm in *S. birrea* to 98.5±23.99 cm for *Z. mauritiana*. There is a significant difference among the species (0.04 < 0.05). For the land use systems, it ranges significantly from 66.77±5.48 cm in savannahs to 113.39±6.46 cm in fallows (0.000<0.001). Nevetheless, the interaction between species and land use systems is not significant (0.95>0.05).

The diameter varies significantly from 0.74±0.2 cm in *S. birrea* to 0.88±0.24 cm in *Z. mauritiana* (0.001<0.01). Concerning the land use systems, stems are vigorous in fallows (0.99± 0.07 cm) than in farms (0.57±0.20 cm). The analysis of variance indicates a significant difference (0.000<0.001). The stems of *Z. mauritiana* has a fast growth with 1.11±0.21 cm in fallows whereas those of small diameter were measured in *S. birrea* in farms (0.53±0.29 cm) (Table 4). The interaction between species and land use systems is not significant (0.75>0.05).

Table 4. *Diameter of the reiterations according the species * land use systems interaction.*

Land use systems /Species	Farms	Fallows	Savnnahs	Mean
Balanites aegptiaca	0.57 ± 0.14	0.92 ± 0.32	0.81 ± 0.34	0.76±0.27b
Sclerocarya birrea	0.53 ± 0.29	0.93 ± 0.35	0.77 ± 0.34	0.74±0.2b
Ziziphus mauritiana	0.64 ± 0.16	1.11 ± 0.21	0.92 ± 0.24	0.88±0.24a
Mean	0.57±0.20c	0.98±0.29a	0.83±0.31b	0.79±0.26

Means followed by different letters are significant at P < 0.05



DS = Distal suckers, PS = Proximal suckers

Figure 6. *Number of suckers according their polarity following species versus land use systems.*

3.3.2. Seedlings

The mean height of the seedlings ranges from 60.08±39.44 cm for *S. birrea* to 80.93±24.12 cm in *Z. mauritiana*. The analysis of variance indicates significant difference among species (0.00<0.001). From the savannahs to the Fallows, the mean height of seedlings oscillates significantly between 53.48±2.52 to 94.8±15.18 cm (0.00<0.001). The interaction between species and land use systems is significant (0.000<0.001).

The mean diameter ranges from 0.62±0.32 cm in *S. birrea* to 0.92±0.26 cm for *Z. mauritiana*. There is a significant difference among the species (0.000<0.001). According to the systems, it varies equally significantly from 0.63±0.01 cm to 0.96±0.21 cm in fallows (0.00<0.001). The interaction between species and land use systems is significant (0.000<0.001).

3.3.3. Suckers

The mean sucker height fluctuates from 28.45 ± 12.97 cm in *B. aegyptiaca* to 46.03±12.2 cm in *Z. mauritiana*. There is a significant difference among the species (0.03<0.05). The three species presented a height two times higher in fallows than in farms. Among the systems, it raises significantly from 28.42±10.88 cm in farms to 55.89±12.46 cm in fallows (0.00<0.001). Meanwhile, the shortest height of suckers are found in *B. aegyptiaca* (16.09±25.16 cm) in farms whereas the highest are in *S. birrea* (65.92±61.87 cm) in fallows. The interaction between species and land use systems did not show significant variation (0.87>0.05).

The diameter of the suckers varies from 0.39±0.19 cm in *S. birrea* to 0.57±0.15 cm in *Z. mauritiana*. Despite the variability observed, there is not a significant difference among the species (0.07>0.05). According to the land use systems, it ranges from 0.37±0.41 cm in the farms to 0.62±0.7 cm in fallows. There is a significant difference among the systems (0.007<0.01). The diameter of suckers raises from 0.27±0.41 cm for *S. birrea* in farms to 0.72±0.7 cm in *Z. mauritiana* in fallows. Meanwhile, there is not a significant difference between species and land use systems interaction (0.6<0.05).

3.3.4. Sucker Polarity

Sucker polarity varies from one species to another. The number of distal suckers in *B. aegyptiaca* and *S. birrea* is greater than proximal one in all the land use systems. The dominant distal polarity of *B. aegyptiaca* and *S. birrea* suckers is contrary to the proximal position of *Z. mauritiana* (Figure 6). *Z. mauritiana* has a priority for proximal polarity.

4. Discussion

4.1. Distribution of the Species

In the three species, the allocation of stems is not uniform in explorated land use systems. The ecological conditions prevailing in sahel in general and in land use systems in particular, are variable. Edaphic factors in addition to zooanthropic activities could be at the origin of such heterogenousness. Such behaviour was reported in *Vitellaria paradoxa* population in the guinean savannah highlands of Cameroon [2]. The demography structure of the population of the tree species involved in the study shows that the density of each species is not homogeneous in different land use systems of the area of Ouaddaï. *Z. mauritiana* has shown a density of 6.08±1.36 stems.ha^{-1}. This figure does not reflect the findings obtained in the same species in sudanian zone of Chad [10]. In the same line, the density of 6.4±2.84 stems.ha^{-1} obtained in *S. birrea* in savannahs is less than what was reported in Niger (13.2±17.51 stems.ha^{-1}) [11] and on protected vegetal formations in Benin (27.6 ± 3.8 stems.ha^{-1}) [12]. This finding on low population density is due to anthropic pressures through trees cutting and agricultural clearing activities. These practices contribute to land cover degradation and fragmentation of natural habitats of some species. Similar findings were reported in the sahel of Niger where diameters of trees in farms were significantly large than that of those in savannahs [13, 14]. Predominance of trees of big diameters in farms expresses the regular maintenance kept by farmers in the same way as for crops [2]. Lack of trees of large diameter in savannahs explains the high anthropique pressure on plant species by local population. These results corroborate those reported in northen Benin on *S. birrea* [12]. It is urgent to enrich the population of *B. aegyptiaca*, *S. birrea* and *Z. mauritiana* through low coast techniques like root suckering and transplantation of suckers in land use systems [15, 16].

4.2. Regeneration of Species

In the space and time, the three species show different variable strategies. Two strategies can be distinguished: an investment to colonize the space; another for the survival of the individual. It is both a colonization and individualization phenomenon [9]. The total number of juvenile stems was 10151, made up of 59.58% reiterations (mainly crown sprouts), 33.62% seedlings and 6.79% suckers. These strategies are low compared to those (12 947 seedlings) recorded in sahelo-sudanian area of Burkina Faso [17]. The predominance of broken collarbones which is due to the decline of mother – tree is in relation to the effect of repeated droughts and bushfires. The increase of seedlings in fallows in all the three species is linked to the soil fertility and lack of disturbance in the fallow. In the same line, the high number of stump shoots are the fact of the mother - tree depletion due to regular droughts and busfires.

4.3. Natural Suckering

The percentage of the natural suckering varies according to species. In farms, the percentage of trees which stools was 5.9% in *B. aegyptiaca* whereas 11% in *Z. mauritiana* and 10% in *S. birrea*. Analogous findings were reported in Kering in Cameroon [18]. According to these authors, the low suckering observed in *B. aegyptiaca*, was linked to very low root development of superficial roots in the species. The density of suckers varied significantly between savannahs (1.8±0.43 sucker.ha^{-1}) and fallows (3.54±0.73 suckers.ha^{-1}). Similar results were reported by various authors [18-22]. According to them, the suckering importance is variable following the species, the land use systems and disturbing degree. Hence, farms which regularly face anthropique pressures show the high density of suckers. The brutal topping of certain fodder trees or those whose leaves are consumed can, in some cases, induce suckering [20]. The diameter of the mother – root does not affect the suckering process. At the same time, the suckering rooting percentage

varies significantly between the land use systems. Rooted suckers are abundant in fallows and savannahs. Those rooting percentage were 38.82% in *B. aegyptiaca*, 37.98% in *S. birrea* and 42.85% for *Z. mauritiana*. The value 42.85% registered in *Z. mauritiana* is widely higher than that obtained in sudanian region of Chad [10]. The explanation is that fallows and savannahs are not subjected to regular disturbing, consequently are conducive to sucker rooting of a plant. Disturbances linked to farming clearing are unfavourable to suckers. The polarity of suckers are in the majority distal in *B. aegyptiaca* and *S. birrea* independently of land use systems. *Z. mauritiana* has a priority for proximal polarity. This finding corroborates the one reported in sudanian area of Chad where the same species exhibited 73% of proximal suckers [10].

4.4. Suckers Emergence Distance

Majority of suckers recorded during root system excavation works in sub-plots are located under the canopy. These results are similar to those reported in *Robinia pseudoacacia* and in *Isoberlinia* [23, 24]. It varies from 56.49 ± 54.57 cm in *Z. mauritiana* to 141.11± 81.21cm for *S. birrea*. The sucker emergence distance in relation to the mother – tree varied significantly according to species. In *Z. mauritiana*, the maximal emergence distance of the first shoot in relation to the mother-tree is 57.54±42.2 cm for fams, 93.93±38.04 cm in fallows and 47.12±35.99 cm for savannahs. These results are similar to those who obtained maximal sucker in relation to mother-tree at 61.02±37.47 cm in *Z. mauritiana* in farms and 96.95 ± 32.88 cm in fallows in Gounou-gaya in sudanian zone of Chad [10]. However, this distance is low compared to what was obtained in others tropical ligneous species. For *Bombax costatum*, sucker emergence distance of mother – tree can reach 15m [25]. In some species, suckering was observed at a distance more than 20 m from the foot of the mother – tree in *Sorbus torminalis* [26]. The widest distance measured between two trees of the same genotype was 80 m [27].

4.5. Regeneration Growth of Species

The limited size of the seedlings in farms in all the three species is in relation to the poor growth and can be explained by the clearing of farm, the gathering of fruits or the localisation of juvenile individuals under the canopy of trees. The perfect illustration is given in *S. birrea*. On the other hand, the growth in size of young plants is favoured by the importance of fallow which is not disturbed by land-clearing activities and allows the restoration of its fertility [2]. Findings of the same nature were reported in Burkina Faso [28] and Togo [29]. However, the present results contradicts those of author who argues that competition in set-aside is detrimental to seedling growth [30]. Species which fruits and/or seeds are eaten, encounter regeneration problems [31]. It is the case of *B. aegyptiaca*, *S. birrea* and *Z. mauritiana* which fruits are consumed and valued [5, 6, 32].

The height and the size of suckers were significantly high between farms and the two others land use systems. Highest and biggest suckers are from fallows and savannahs. Anthropique pressures due to farms clearing activities and ploughing, influence negatively the normal growth of suckers. Mean diameters are generally more broad in fallows than in farms and savannahs. They were 0.99±0.07 cm for reiterations, 0.96±0.21 cm for seedlings and 0.61±0.11 cm in suckers. Reiterations and seedlings are wider than suckers. These results are analogous to those reported in *Vitellaria paradoxa* in Burkina Faso [17]. Highest and biggest suckers come from fallow and savannahs. These findings are similar to those reported on fallows which the impact is favourable to the growth of suckers while disturbance linked to farm clearing shackles it [2].

5. Conclusion

Dendrometric characterization contributed to know the population structure of *B. aegyptiaca*, *S. birrea* and *Z. mauritiana* in the sahelian zone of Ouaiddaï. This is therefore a fundamental prerequisite for implementing effective management and conservation strategies for these species. The low density of these species indicates that they are vulnerable to drought and, above all, to over-exploitation. Except in farms, trees from others land use systems present a low structure of diameter. Naturally, each of these species regenerates by three modes: germination, root suckering and stump shoot. Natural root suckering is the lowest mode compared to the two others. The suckers of the three species have the ability to root, suggesting the possibility of self – pruning and self-empowerment in the future. The ecological conditions of fallows are favourable to suckering, growth and rooting. The suckering percentage observed in each land use systems indicates that each of the species is suitable for suckering. The natural regeneration percentage is low in each species and in each land use systems. The findings obtained in this work will contribute to the management programme and sustainable conservation of these species through development of low coast domestication technics such as root suckering.

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