

Morphological variability of *Sclerocarya birrea* (A. Rich.) Hochst. subsp. *Birrea* (Anacardiaceae family) in the Ouaddaï Province, Chad

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International Journal of Frontline Research in Science and Technology, 2022, 01(01), 019–030

Publication history: Received on 14 February 2022; revised on 29 March 2022; accepted on 31 March 2022

Article DOI: <https://doi.org/10.56355/ijrst.2022.1.1.0005>

Abstract

The involvement of local population in forest management is nowadays a major issue. It is with this in mind that this work was carried out and should lead to the subsequent domestication of the species. Its objective has been to develop strategies for the conservation and sustainable use of the *Sclerocarya birrea* (A. Rich.) Hochst genetic resources. The methodological approach focused on the farmer's survey and the botanical inventory. The socioeconomic survey was carried out in the villages of Arkou, Kokorguin and Mandafana among the Maba, Massalit, Mimi and Tama populations. One hundred and seventy-two (172) people were involved in the investigation. Botanical analyzes focused on 15 quantitative morphological descriptors. The farmers in the region have a good knowledge of this plant and have an empirical classification system that incorporates 11 criteria according to ethnic groups. The criteria common to the 4 targeted ethnic groups are: the habitat and size of the tree, the dimensions of the fruit, the shape of the fruit, the taste of the pulp and the size of the leaves. The botanical inventory made it possible to determine the discriminating morphological descriptors for this species in the region. These are: the height of the first large branch ($0.016 < 0.05$), the height of the tree ($0.029 < 0.05$) and the average diameter of the crown ($0.008 < 0.01$). Analysis of the different descriptors revealed 4 morphotypes in *Sclerocarya birrea* (A. Rich.) Hochst. This information opens up better prospects for varietal selection and domestication of this species in the area.

Keywords: Sahelian zone; *Sclerocarya birrea*; Peasant perceptions; Morphotypes; Domestication

1. Introduction

The African plum tree, *Sclerocarya birrea* (A. Rich.) Hochst is an Anacardiaceae very widespread in the Sahelo-Sudanian zone where it is of significant traditional interest [1]. *Sclerocarya birrea* (A. Rich.) Hochst is a common and widespread species throughout the semi-arid, deciduous savannas of much of sub-Saharan Africa [2]. In the Chadian Sahel, where droughts are frequent, the African plum or *Sclerocarya birrea* occupies a central place in the life of rural communities. It is one of the spontaneous woody plants most exploited for human consumption [3]. The main product used is the fruit [4]. Oil extracted from the seed is used for family consumption or in the cosmetic industry [5]. Fruits and bark are used in traditional medicine; trunks and branches to manufacture household items such as mortars and pestles [6]. Its products are commonly sought after and sold in most local and regional markets [7]. These multiple purposes lead to an increased pressure on the populations of the species. *Sclerocarya birrea* (A. Rich.) Hochst therefore has a direct impact on household income. However, the species is unfortunately vulnerable due to overexploitation and especially its low rate of regeneration [8]. Its natural regeneration is very low which suggest an increasing risk of extinction of the

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species in this forest ecosystem [9]. Overexploited, threatened by bush fires and drought, *Sclerocarya birrea* (A. Rich.) Hochst is in marked extinction. To face this major challenge, it therefore appears urgent to develop strategies to improve the production and productivity of this species in order to meet the ever-growing needs of the population.

Therefore, studying the morphological variability of *Sclerocarya birrea* (A. Rich.) Hochst is an important step in its domestication. This also involves prioritizing and taking into account the experiences and preferences of local populations in the field of plant conservation and enhancement. The domestication of a plant species also requires the identification of seed-producing species, knowledge of morphological characteristics and the development of propagation techniques [10, 7]. *Sclerocarya birrea* (A. Rich.) Hochst local ecological data Knowledge is inexistent and therefore little known. Therefore, this study was initiated to allow subsequent domestication of *Sclerocarya birrea* (A. Rich.) Hochst in the province of Ouaddaï. Focused initially on the study of the morphological variability of the species, this work is part of the promotion and protection of this threatened species. The main objective is to contribute to the development of strategies for the conservation and sustainable use of the genetic resources of the species.

2. Material and methods

2.1 Study site

The study was carried out in Ouaddaï, Province in eastern Chad. Located between the 12th and the 16th parallel north and 200 to 600 mm isohyets, this province is in the Chadian Sahel. With an area of 29,980 km², the study area has 731,679 inhabitants and the investigations concerned three (3) village areas: Arkou (13° 52' N and 20° 49' E), Kokorguin (13° 29' N and 20° 39' E) and Mandafana (13° 54' N and 20° 42' E) (Figure 1).

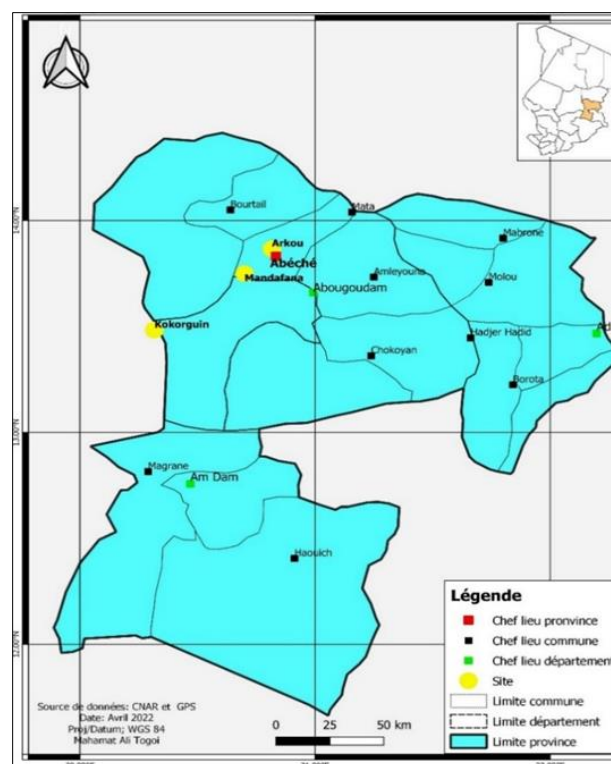


Figure 1 Location of study sites

This zone is influenced by a Sahelian type climate with a long dry season (November to May) and a short rainy season (June to October). The average annual rainfall is between 200 mm in the North and 950 mm in the South. The temperature of the region varies according to the season. During the cold dry season (December / February), daily temperatures are on average between 16 and 35 °C; in the hot dry season (March / April), temperatures fluctuate between 25 and 41 °C; in the rainy season (August), they decrease and vary between 21 and 31 °C.

The very rugged relief is marked by rocky outcrops as well as the presence of stones, boulders and rocks. The Province is crossed by rivers which are mostly non-permanent and endorheic, the duration of which depends on the variability of rainfall and their position in the Province.

2.2 Socioeconomic surveys (inquiry)

Socio-economic surveys inspired by the work of Mapongmetsem et al., [10] were carried out among the population. The objectives of these surveys are as follows:

- Identify and update local knowledge on the species;
- List and analyze the identification criteria used in the traditional classification;
- Identify, with the involvement of the peasants, the best morphotypes of this species.

The investigations or inquiries concerned three (3) village areas: Arkou, Kokorguin and Mandafana. The ethnic groups targeted are the Maba (48 people), Massalit (40 people), Mimi (41 people) and the Tama (43 people). A total of 172 people were interviewed including 94 men and 78 women on a voluntary basis. The semi-structured interviews conducted using a questionnaire containing closed and open questions. The individuals targeted in this survey are elderly people of both sexes because of their experiences. The individual interviews were supplemented by group interviews. The number of people per group varied between 5 and 15.

2.3 Evaluation of morphological descriptors

The identification of individuals was carried out by the peasants themselves who, after the interview, went with us to the field to identify the tree in question. The assessment concerned 10 individuals of the species (Figure 2) in the course of fruiting per site, or 30 individuals for the three observation sites. In each site, the selected individuals are at least 100m apart.



Figure 2 An individual of *Sclerocarya birrea* (A. Rich.) Hochst

2.4 The dimensions of the tree

2.4.1 The trunk

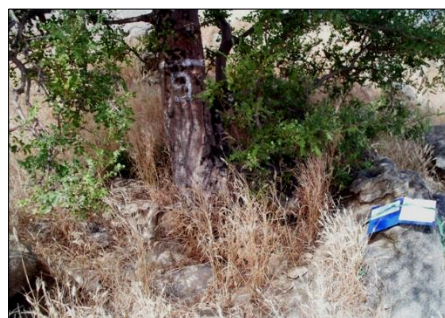


Figure 3 Circumference measurement at 1.30m above the ground

The morphological descriptor retained at the level of the trunk is the diameter at breast height (DBH) taken at 1.30m from the ground. It was measured using a tape measure. The measure concerned 10 trees per site, or a total of 30 trees for the 3 sites. Each tree identified by the farmers was numbered with the paint (Figure 3).

2.5 The height of the tree and the first living branch

The height of the first large living branch and the overall height of the tree were estimated using the clinometer. The measurement concerned a total of 30 individuals, i.e. 10 individuals per site. The insertion height of the first large living branch is very interesting as it gives an idea of the accessibility to the tree canopy.

2.6 Leaves and leaflets

The length and width of the leaves and leaflets were measured using a 30 cm ruler (Figure 4). For each tree, 10 leaves or leaflets were measured, i.e. a total of three hundred (300) leaves for the 30 trees selected. The number of leaflets per leaf was determined by simple counting. For this species, the Raunkier formula adapted by Noubissié et al., [11] on compound leaves was used to determine leaf areas.

$$SF = 2/3 \sum n_i = 1 (L_n \times l_n)$$

L = greatest length;

l = greatest width;

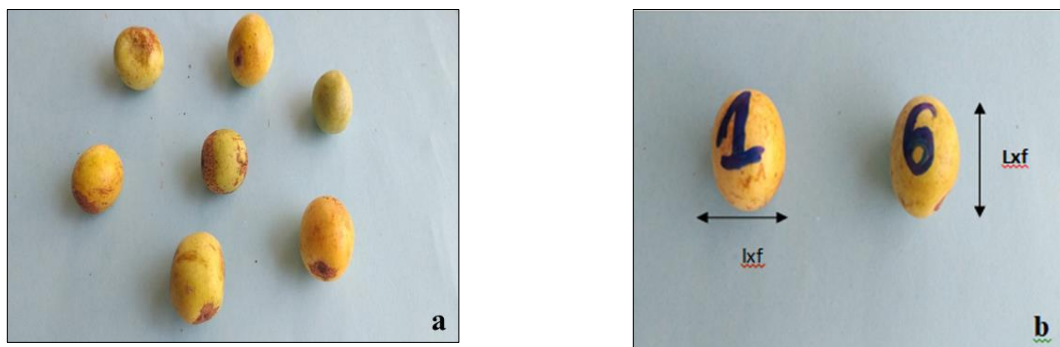
n = number of leaflets



Figure 4 Leaf of *Sclerocarya birrea* (A. Rich.) Hochst

2.7 The fruits

The measurements concerned 10 ripe non-parasitized fruits per individual. The fruits of *Sclerocarya birrea* (A. Rich.) Hochst (Figure 5) were harvested in June 2020.



Lxf = Length of the major axis; lxf = Length of the minor axis

Figure 5 a) Different fruits of *Sclerocarya birrea* harvested; b) measurement of the dimensions of the fruits

The harvest was carried out by climbing directly on the tree. The dimensions of the major and minor axis of the fruit were determined using a graduated ruler. The length of the major axis of the fruit was measured from the point of attachment of the fruit to the peduncle to the end of the fruit. The weights of the various fruits and of the pulp were obtained using an AND balance of type HT 300, sensitive to 1%. The razor blade cleared the pulp from the endocarp.

2.8 Seeds

A total of three hundred dry seeds were measured (Figure 6).



Figure 6 Different dry seeds of *Sclerocarya birrea*

The descriptors retained for the seed are the major and the minor axis, and the weight. The dimensions of the major and minor axis of the fruit were determined using a caliper. The seed weight was determined using a sensitive 1% AND balance type HT 300.

2.9 Data analysis

The data collected was subjected to an analysis of variance. The significant descriptors were then subjected to principal component analysis (PCA) and hierarchical ascending classification. The software used are Stratigraphic Plus for ANOVA and XLSTAT for ACP.

3. Results

3.1 Traditional classification of the tree

3.1.1 The size of the leaflets

Majority of Massalit (64%), Maba (69%), Mimi (51%) and Tama (74%) recognize the sex of trees from the size of the leaflets. These populations distinguish:

- Individuals with small leaflets which never produce fruit;
- Individuals with large leaflets which are productive.

3.1.2 Topographic position of the tree

The situation of the tree on the ground is a source of inspiration for the Ouaddaïen peasant. The percentage of respondents varies between 58% and 89% among the Maba. People claim that large trees are only dependent on the sandy soil of the plains and the Ouadis. Compared to the topographical situation, 66% of the Maba and 73% of the Massalit state that the species can also be found in the mountains.

3.1.3 Fruit size, shape and taste

The size of the fruit, its shape and its taste constitute a classification criterion for 76% of Massalit questioned. The combination of these criteria allows them to distinguish 4 types of individuals within the species. It is:

- Individuals with small rounded and acidic fruits;
- Individuals with large rounded and acidic fruits;
- Individuals with large, rounded and sweet fruits;
- Individuals with small elongated and sweet fruits.

For the same combination of criteria, the Mimi (61%), the Maba (76%) and the Tama (64%) recognize the existence of two types of individuals:

- Individuals with large rounded and acidic fruits;
- Individuals with large rounded and sweet fruits.

3.2 Characterization of the species

3.2.1 Morphological descriptors of the trunk

For the character trunk diameter measured at 1.30 m, 85% of the total population have a diameter between 20 and 40 cm. The trunk variation measured at chest height is 31.42 ± 0.08 cm at Mandafana and 34.45 ± 0.06 cm at Kokorguin. The average diameter is 33.03 ± 0.07 cm. For this parameter, there is no significant difference between individuals of this species in terms of diameter ($0.118 > 0.05$).

3.2.2 Morphological descriptor of the height of the first large branch

The variation between individuals of *Sclerocarya birrea* (A. Rich.) Hochst for the height of the first branch is 1.88 ± 0.95 m at Arkou and 2.96 ± 0.75 m at Kokorguin. The average height of the first living branch in *Sclerocarya birrea* (A. Rich.) Hochst is 2.57 ± 0.60 m. There is a significant difference between individuals ($0.016 < 0.05$).

3.2.3 Morphological descriptor of the average crown diameter

The value of the mean crown diameter in *Sclerocarya birrea* (A. Rich.) Hochst varies between 7.67 ± 1.61 m in Arkou and 10.52 ± 2.46 m in Mandafana. There is a significant difference ($0.008 < 0.01$). The average crown diameter is 9.19 ± 1.43 m.

3.2.4 Morphological descriptor of tree height

The height variation varies between 6.62 ± 1.37 m in Arkou to 7.97 ± 1.39 m in Kokorguin. The average height is 7.44 ± 0.72 m. There is a significant difference ($0.029 < 0.05$) between the height of trees at different sites (Table 1).

Table 1 Shaft dimensions (of the tree)

Sites	Diameter at chest height (cm)	Height of the 1st branch (m)	Average crown diameter (m)	Tree height (m)
Arkou	$33,24 \pm 0,08$ a	$1,88 \pm 0,95$ a	$7,67 \pm 1,61$ a	$6,62 \pm 1,37$ a
Kokorguin	$34,45 \pm 0,06$ a	$2,96 \pm 0,75$ c	$9,39 \pm 1,94$ b	$7,97 \pm 1,39$ b
Mandafana	$31,42 \pm 0,08$ a	$2,88 \pm 0,57$ b	$10,52 \pm 2,46$ c	$7,74 \pm 1,21$ b
Moyenne	$33,03 \pm 1,52$	$2,57 \pm 0,60$	$9,19 \pm 1,43$	$7,44 \pm 0,72$

Averages followed by the same letter are statically identical

3.2.5 Morphological descriptors of leaves and leaflets

The length of the leaflets in *Sclerocarya birrea* (A. Rich.) Hochst varies between 31.15 ± 5.46 mm in Mandafana and 32.69 ± 3.43 mm in Kokorguin. The average length is 31.84 ± 0.78 mm. There is no significant difference ($0.845 > 0.05$) between individuals for the leaflet length criterion. For the width of the leaflets, the variation is 20.03 ± 0.73 mm at Arkou and 20.27 ± 0.64 mm at Mandafana. The average is 20.12 ± 0.12 mm. There was also no significant difference ($0.623 > 0.05$). The leaf area oscillates between 642.79 ± 126.70 mm² in Kokorguin and 643.82 ± 156.57 mm² in Mandafana with an average of 649.71 ± 11.10 mm² (Table 2). These values are not significant either ($0.944 > 0.05$).

Table 2 Leaflet characteristics

Sites	Length (mm)	Width (mm)	Leaf area (mm ²)
Arkou	31,69±3,20 a	20,03±0,73 a	642,79±126,70a
Kokorguin	32,69±3,43 a	20,08±0,45 a	662,52±119,95a
Mandafana	31,15±5,46 a	20,27±0,64 a	643,82±156,57a
Moyenne	31,84±0,78	20,12±0,12	649,71±11,10

Averages followed by the same letter are statically identical

3.2.6 Morphological descriptors of the fruit

Table 3 shows the different characteristics of the fruits of *Sclerocarya birrea* subsp. *Birrea* (A. Rich.) Hochst. The length of the major fruit axis is 2.55 ± 0.21 cm at Kokorguin and 2.66 ± 0.14 cm at Arkou. The average is 2.6 ± 0.05 cm. This difference is only apparent since there is not a significant difference ($0.331 > 0.05$) between the fruits of individuals from one site to another. It is the same for the variation in length of the minor axis ($0.658 > 0.05$) which is 2.39 ± 0.89 cm at Mandafana and 2.66 ± 0.51 cm at Kokorguin with an average of 2.49 ± 0.14 cm.

The weight of the fruits varies between 14.97 ± 3.81 g in Mandafana and 16.60 ± 2.06 g in Arkou. The fruits weigh on average 15.56 ± 0.90 g. As in the previous case, there is no significant difference between the weights of the different fruits ($0.557 > 0.05$). The pulp weighs 7.66 ± 1.75 g in Mandafana and 8.04 ± 0.96 g in Arkou for an average of 7.86 ± 1.64 g. There is no significant difference ($0.869 > 0.05$).

Table 3 Characteristics of the fruits

Sites	Lxf (cm)	lxf (cm)	Pf (g)	Ppu (g)
Arkou	2,66±0,14 a	2,44±0,48 a	16,60±2,06 a	8,04±0,96 a
Kokorguin	2,55±0,21 a	2,66±0,51 a	15,12±4,91 a	7,88±2,23 a
Mandafana	2,59±0,21 a	2,39±0,89 a	14,97±3,81 a	7,66±1,75 a
Moyenne	2,60±0,05	2,49±0,14	15,56±0,90	7,86±0,19

Averages followed by the same letter are statically identical; Lxf = Length of the major axis; lxf = Length of the minor axis; Pfr = Fruit weight; Ppu = Pulp weight;

3.2.7 Morphological descriptor of seed weight

For the seeds, the weight varies between 1.99 ± 0.36 g in Mandafana and 2.21 ± 0.30 g in Arkou. The average seed weight in the 3 sites is 2.09 ± 0.39 g (Table 4). As before, this observed difference is not significant ($0.554 > 0.05$).

3.3 Principal Component Analysis

The different morphological descriptors are subjected to principal component analysis (PCA). The variability is between 17.78% in F2 and 68.19 in F1. The cumulative percentage for the two axes is 85.98% in F2. This result indicates that the axes F1 and F2 express almost all of the variables analyzed (Figure 7).

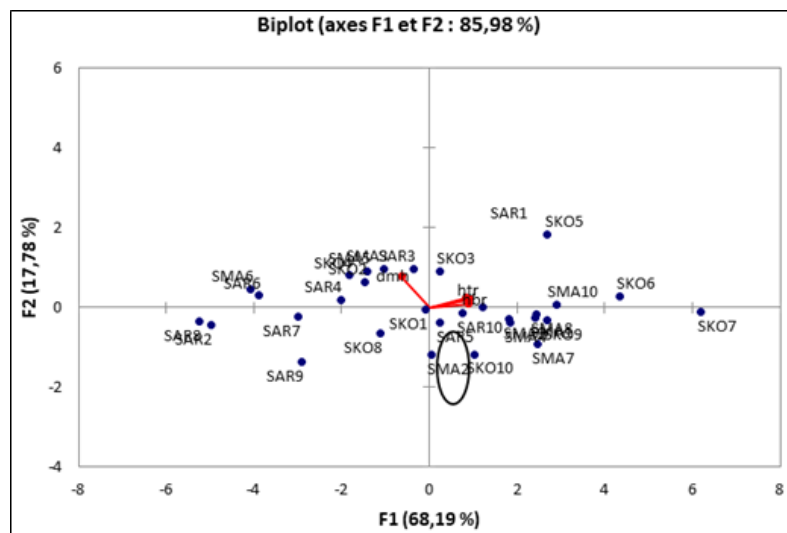
Examination of the distribution of this species shows that individuals of this Anacardiaceae are not uniform in space. This is justified by the observation of four (4) point clouds made up as follows:

- A first cloud of points grouped around the overall height of the tree, the average diameter of the crown and the height of the first large living branch. This cloud is formed by trees n ° 1, 5 and 10 of Arkou, trees n ° 3, 5, 6, 9, 10 of Kokorguin and trees n ° 1, 4, 7, 8, 9 and 10 of Mandafana ;
- A second cloud made up of dots surrounding the length of the fruit. This group is represented by individuals n ° 3, 4 and 6 of Arkou, trees n ° 3, 5 and 6 of Mandafana and trees n ° 2 and 4 of Kokorguin;
- The third cloud is made up of trees that are not linked to any variable studied. The representatives of this group are trees n ° 2, 7, 8 and 9 of Arkou and 5 of Kokorguin.

Table 4 Summary of morphological descriptors assessed

Settings	Probabilities
Sheet length (mm)	0,845 ns
Sheet width (mm)	0,623 ns
Sheet area (mm ²)	0,944 ns
Leaflet length (mm)	0,644ns
Leaflet width (mm)	0,976 ns
Length of the major axis of the fruit (cm)	0,331 ns
Length of the small axis of the fruit (cm)	0,658 ns
Fruit weight (g)	0,557 ns
Pulp weight (g)	0,869 ns
Height of the first big branch (m)	0,016*
Seed weight (g)	0,554 ns
Diameter at chest height (cm)	0,118 ns
Tree height (m)	0,029*
Average crown diameter (m)	0,008**

ns = not significant; * = significant at 5%; ** = significant at 1%

**Figure 7** Distribution of *Sclerocarya birrea* in space

The last cloud is made up of a single individual: tree n ° 2 of Mandafana.

A more in-depth analysis from the hierarchical classification made it possible to develop the dendrogram grouping the 30 individuals of *Sclerocarya birrea* (A. Rich.) Hochst (Figure 8).

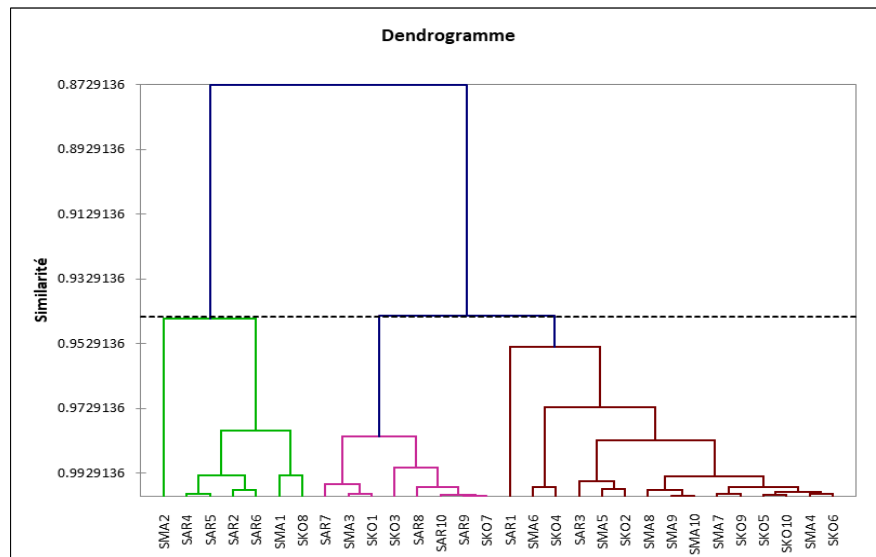


Figure 8 Dendrogram of the different morphotypes of *S. birrea*

The critical similarity index is at the 94% level. Two individuals do not belong to any subgroup. These are individuals n°2 from Mandafana and n°1 from Arkou. The 4 morphotypes are distributed as follows:

- A first morphotype represented by large trees ($8.3 \pm 1.14\text{m}$), with high branches ($3.7 \pm 0.63\text{m}$) and a high pulp weight ($8.94 \pm 1.70\text{g}$). It is represented in the 50% zone;
- A second morphotype made up of large trees ($7.5 \pm 1.35\text{m}$), with low branches ($2.6 \pm 1.00\text{m}$) and a lower pulp weight ($7.46 \pm 1.35\text{g}$). It is present at 20% in the area;
- The third morphotype consists of trees of small size ($6.2 \pm 1.60\text{m}$), with low branches ($2.4 \pm 1.09\text{m}$) and with a high pulp weight ($8.32 \pm 1.53\text{g}$) and which constitute 26.66% of the total;
- The last morphotype consists of Mandafana tree n° 2 only. It constitutes 3.33% of the total.

The analysis of the quantitative morphological descriptors of the 4 identified morphotypes confirms the peasant classification. Apart from morphotype 4, there are subtypes within types.

4. Discussion

The peasants of this region have knowledge of the studied species. They use *Sclerocarya birrea* (A. Rich.) Hochst and have preferences for certain individuals. Depending on the ethnic groups, 11 criteria are used to identify individuals of this species. The main criteria used by farmers to distinguish individuals of this species are related to the size of the trees, the morphology of the leaves and fruits and the taste of the pulp. These criteria vary according to the ethnic group. In peasant perception, there is a symbolism relating to the sex of the tree. This is how these populations distinguish between male and female individuals in *Sclerocarya birrea* (A. Rich.) Hochst on the basis of the size of the leaflets. Previous studies carried out by Brahim et al., [7] in the same region, show that Ouaddaïan peasants have always used their own criteria to differentiate between individuals of *Balanites aegyptica* (L.) Del. and *Ziziphus mauritiana* Lam. In the high Guinean savannas of Cameroon, Mapongmetsem [12] reports a similar classification of trees among indigenous populations.

In Benin, Fandohan [13] identified 10 morphotypes of *Tamarindus indica* L. using the farmer classification based on pulp taste and habitat types. In Burkina Faso, the farmers of Thiougou recognize the fruitless individuals of *Vitellaria paradoxa* C.F. Gaertn. from the presence of cracks at the base of the trunk or of the bushy foliage [14]. This knowledge is linked to the different categories of use of these trees by farmers.

The observation of the means of the height of the first living branch and the mean diameters of the crown in individuals of *Sclerocarya birrea* (A. Rich.) Hochst shows a significant difference between individuals ($0.016 < 0.05$ and $0.008 < 0.01$ respectively). This means that the crown diameter and tree height characteristics of *Sclerocarya birrea* (A. Rich.) Hochst are influenced by the environment. Furthermore, the difference between the mean seed weight observed in the 3 study sites is not significant ($0.554 > 0.05$). The height of the tree and the first living branch are useful for domestication

because the crown represents more than 70% of the volume of savannah trees [15]. These results show that the quantitative descriptor of the seed weight in *Sclerocarya Birrea* (A. Rich.) Hochst is not influenced by the environment.

The evaluation of morphological descriptors carried out during our study showed that *Sclerocarya birrea* (A. Rich.) Hochst exhibits significant intraspecific variability both within a population of a site and between populations of different sites. Our results are comparable to those obtained by Bationo/Kando et al., [16] and Leakey et al., [17]. Our results further showed that there is no link between the morphological characters of trees and the characteristics of the fruit and / or the seed. These results show that one can meet large and small trees bearing large or small fruits. They corroborate the results of Leakey et al., [18] and Bationo-Kando et al., [16]. Leakey et al., [19] also showed a significant variation for the weight of the fruit, the pulp and the fruit tegument. However, according to Bationo-Kando et al., [16], it is difficult to establish clear links between the different morphological characters of individuals.

The mean values measured for the total height and that of the crown and the diameter of the trees are in the range of those obtained by Sérémé [20] and Bation / Kando et al., [16]. With reference to the work of Soumaré et al., [21], the average height (7.44 m) and the average diameter (33.03 cm) of the tree indicate that the average age of the individuals measured must vary between 19 and 32 years. The populations of *Sclerocarya Birrea* (A. Rich.) Hochst studied therefore appear to be aging and must therefore encounter a real problem of natural regeneration.

Principal component analyzes allowed to observe significant and positive correlations between the height of the tree ($r = 0.825$; $P < 0.05$) and the first large branch. The mean crown diameter ($r = 0.728$; $P < 0.05$) is also positively correlated with the height of the first large branch. This means that trees with a large size and a broad canopy have a taller first branchial branch. These criteria are very interesting for future domestication programs as it gives an idea about wood production and accessibility to the tree canopy. Other studies have found great variability in dry savanna species in these parameters. In Mali, the study of morphological variability in *Detarium microcarpum* Guill. & Perr. [15] showed significant variations in the circumference of the trunk taken at 1.30m from the ground. The work of Lovett and Haq [22] also found in Ghana a great variability in diameter at breast height in *Vitellaria paradoxa* C.F. Gaertn. Other descriptors such as the dimensions of the fruits, the weight of the seeds do not constitute a criterion of discrimination between the individuals of these species in the study sites. The average fruit weight of *S. birrea* (A. Rich.) Hochst which is 15.56 ± 0.90 g is lower than that obtained in Benin by Gouwakinnoun and Sinsin, [23] which is $18.25 \pm 0, 26$ g. However, these authors showed that the weight varied significantly according to the ecological zone.

The dendrogram obtained from the analysis of the hierarchical classification confirms the results of the PCA. By grouping the 30 individuals of *Sclerocarya birrea* (A. Rich.) Hochst according to their similarity index, we obtained 4 morphotypes and 9 main subgroups of *Sclerocarya birrea* (A. Rich.) Hochst. The analysis carried out from the hierarchical classification on the basis of characters (overall height, average diameter of the crown, height of the first large living branch and the length of the fruit) made it possible to distinguish 4 morphotypes which could be influenced by the conditions. The environment in which the individuals of the species develop. The distinction between the four groups was made mainly on the basis of characters (characters of the fruits and seeds of trees) which can be influenced by the environmental conditions in which the trees live. The influence of genotype on the expression of these traits is not yet established. The distribution of the trees in the 4 defined morphotypes shows that each type is found in almost all the sites.

These results show that the populations of *Sclerocarya birrea* (A. Rich.) Hochst in this region are not uniform. Morphotypes of interest for setting up breeding and domestication programs for this species are: large individuals, with low branches and high pulp weight. The data identified at the end of this work could contribute to the selection of superior trees responding to the concerns of peasant communities and the market.

5. Conclusion

The success of a forest development and management program depends above all on the degree of involvement of the local populations. This is why we have associated peasant perceptions in the selection of morphotypes. The study found that these farmers in the Ouaddai region of Chad hold knowledge about the species in question and have an empirical classification system that incorporates up to 11 criteria according to ethnic groups. The criteria common to the 4 ethnic groups are: the size of the tree, the size of the fruit, the shape of the fruit, the taste of the pulp and the size of the leaves.

The distribution of individuals of this species is not uniform in space. Quantitative morphological descriptors identified 4 morphotypes in *Sclerocarya birrea* (A. Rich.) Hochst. Morphotypes of interest for setting up breeding and domestication programs for these species are: large individuals, with low branches and high pulp weight. The data

collected at the end of this work could contribute to the selection of superior trees responding to the concerns of local populations and the market.

Compliance with ethical standards

Acknowledgments

The authors warmly thank the populations of the three (3) villages of Ouaddaï, Province in eastern Chad for having accepted to share their knowledge and for their frank collaboration in this study.

Disclosure of conflict of interest

The authors declare no conflict of interest.

Statement of ethical approval

The present research work does not contain any studies performed on animals/humans subjects by any of the authors.

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