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Morphopedological Characteristics of Soils under Shea Trees in the Bouna Region of Northeast Côte d'Ivoire

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present study was initiated to characterize the soils of three (03) ecological zones of natural establishment of shea in the region of Boukani, in the north-east of Côte d'Ivoire. The study consisted of opening soil pits for morphological characterization following the approach of the Office of Scientific and Technical Research Overseas, based on in situ observation. Botanical data such as density per square meter, trunk diameter at 1.30 m from the ground and their spatial arrangement were also collected. The areas concerned are the villages of Gnarkèradouo, Assoum

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2 and Nakélé. The results observed show a significant difference between sites. The shea park is denser in Gnarkèradouo (44.16%), followed by the Assoum 2 park with 38.32% of shea trees and finally the Nakélé site where 17.52% are observed. For the circumference of trees at 1.30 m from the ground, the results show that it is at Nakélé that large trees are observed with high values of 144 cm, then at Assoum 2 (126.2 cm) and finally at Gnarkèradouo with 114.8 cm.
The characteristics of the soils show similarities on the 3 sites. These are gravelly soils with obstacles (indurations). However, the soil at Assoum 2 appears to be different because it is deep. The texture is sandy-clay on all three sites.

Keywords: Shea; morphopedological characteristics; soil; Côte d'Ivoire.

1. INTRODUCTION

Shea (*Vitellaria Paradoxa*) of the Sapotaceae family is a natural plant of the savannah in central and western Africa [1]. It is found in the Sudano-Sahelian and Sudanese zones. In Côte d'Ivoire, this plant populates the northern part from the V baoulé to the north. Traditionally, the socio-economic and ecological importance of shea is known to African populations in general and Ivorians in particular [2-4]. Indeed, the shea nut (the almond) is used to make butter. This product is rich in fat (45 to 50pc) and is used in the manufacture of cosmetic products (sun protection and against skin irritations), medicinal, as a source of energy, in handicrafts and construction [2,5] and food in chocolate making which gives an added value [3,6,7].

In traditional medicine, all components of the plant (roots, bark, leaves, flowers, fruits) are used. Decoctions of shea leaves, for example, are used for gastric care and headaches; the roots and bark are used for the treatment of diarrhea. An infusion of the bark can neutralize cobra venom [8]. The work of [9,10] in Burkina, [11] in Mali, [12] in Côte d'Ivoire and [13,14] in Benin have shown that the shea tree has impacts on soil quality. Nowadays, several virtues are associated with shea thanks to research placing it at the center of all interests. The ecosystem services rendered by shea are grouped into 4 major categories which are services (provisioning, regulating, cultural and supporting) according to the work of [14]. The traditional sphere of use has now expanded and the demand for it is growing. And this, as well in Africa as in the Western and Eastern countries (the United States, Russia, the Middle East and Saudi Arabia). The shea butter sector is booming nowadays, with its consumption constantly evolving in the world, leading to a mobilization of stakeholders in the sector to improve its production, but it remains unorganized [15]. The Ivory Coast is the 5th largest producer of shea butter [16]. The tree can measure between ten and fifteen meters in height and has a short bole (about three meters) with a diameter of up to one meter. Its lifespan is estimated at two to three hundred years [17]. Its root system is very tortuous, which prevents erosion and favors association with other crops. This species appears in all floristic surveys at the bottom of the slope, frequent at the top of the slope and on the ferrallitic interfluves, exceptional on the cuirasses and in the thalwegs [18].

Since the shea tree is difficult to cultivate, its exploitation by rural populations has retained all its traditional and artisanal aspects, and it is protected by custom, which prohibits its cutting [19]. The shea tree has never been the subject of organized cultivation, particularly because of the number of years it takes to produce any fruit, generally about fifteen or twenty years [19]. The tree reaches full maturity and therefore maximum production only after about twenty-five years. Fruit production is irregular so that almond prices fluctuate from year to year depending on supply and demand [20]. The lack of renewal of adult trees leads to the common belief that regeneration is absent from the fields, yet seedlings appear in the fields even if they do not develop into young trees [21]. The reason is that these seedlings are continuously uprooted during cultivation operations. In addition, their slow growth does not encourage farmers to keep them and let them grow. The result is that the reduction or even absence of young plants dangerously compromises the viability of the parks [21] et al. [22]. Domestication of natural species is an imperative [23] to ensure the sustainability of the species [24] and [25]. The practice of grafting on the shea tree can help reduce the period of maturity, of setting fruit of the shea tree between 5 to 6 years against 20 years [26]. The lack of knowledge of the potential of this species and the sector does not favor its organization [15]. For the development of this sector, which generates income for the actors, it is essential to organize it well. For that, it is necessary to foresee industrial plantations from now on.

The soil is the support of the plant containing water and nutrients responsible for their growth and development. Knowing the soil where shea grows naturally would be an advance for domestication. This study, which took place in Bouna, north-east of Côte d'Ivoire, was initiated with the aim of describing the soil in three shea parks.

2. MATERIELS AND METHODES

2.1 Site Area

Located between latitudes 9°N and 9°48'N and longitudes 2°30'W and 3°W, the Boukani region is 582 km from Abidjan and 166 km from Bondoukou, with Bouna as the regional capital. The region Bounkani is located in the northeast of Côte d'Ivoire, bordering Ghana to the east, Burkina Faso to the north, the Gontougo region to the south and the Tchologo and Hambol regions to the west. The region covers an area of 22.091 km² or 6.9% of the national surface area. However, half of its area is occupied by the Comoé National Park which covers 11,090 km² (Fig. 1) selon INS 2015 [27].

Located in a savannah zone dominated by grass and trees, the Boukani climate is Sudanese with two major seasons, one rainy from June to October (4 to 5 months) and the other dry from November to February (7 to 8 months). The main activity in the area is agriculture, which includes the cultivation of Kponan yams, for which the area is famous, cereals (corn, sorghum and millet), and more recently cashew farming. The Boukani is drained by the Comoé and the Volta Noir (Fig. 2), which favors market gardening. Trade and transportation are not forgotten. The area is also known for its mineral-rich subsoil, particularly gold, which is mined by illegal miners. Livestock farming is an important part of this economy, with poultry, cattle and goat breeding. The Tourism, in particular the Comoé National Park founded in 1968, is also a source of foreign currency. With its surface area (1 150 000 ha), this park is the oldest and most important in Côte d'Ivoire.

Fig. 1. Map of study site

2.2 Materials

The equipment used for this study consists of technical field equipment for orientation, location and opening of pits. The study sites were selected preferably in shea parks near the villages.

2.3 Methods

2.3.1 Discussions with stakeholders

Meetings with stakeholders helped to define the framework of the study. A survey was carried out on 10 households per site in relation to the organization of the sector (survey form).

2.3.2 Description of sites

The sites were chosen for their abundance of shea trees. These sites are shea parks. Thus, the parameters assessed were density, tree circumference at 1.30 m height, distance between plants, and plant homogeneity. The surface condition and vegetation were also described.

Three pits were made, one per site. At each site, the pit was made in the shea park at 10 m as a center of the trees for description.

3. RESULTS

3.1 Description of Shea Farms

The shea parks are close to the villages. The trees were expressly abandoned in view of their importance. These parks offer more or less homogeneous seedlings according to the average age of the plants and their spatial distribution (Fig. 2). The harvest rate is far from 100%, given the number of seeds germinating under the trees. The parks cover important areas, but in constant reduction. Most of them are located on the edge of a gallery forest and cohabit with other woody or hardy and herbaceous species. The soils are strewn with ferruginous laterites.

3.2 Vegetation, Circumference and Density of Plants on the Sites

The vegetation is a wooded savannah consisting mostly of shea and other trees such as *Mucuna pruriens* and *Raphia farinifera*, *Nauclea latifolia* at all three sites. The parks are dense with large trees with large trunks, however, differ from one site to another. The density of plants varies from site to site.

It is estimated at 223 plants per hectare for the Assoum 2 site while at Nakélé (Doropo), 102 plants/ha and 257 plants/ha at Gnakeradouo, the shea trees are sparse and less dense with lateral roots on the surface (Fig. 3). The sites of Assoum 2 and Gnarkèradouo have the same vegetation because these two villages are separated by a river. However, a strong regeneration of Saba senegalensis is observed in Gnarkèradouo followed by young shea plants. Fig. 4 shows the tree circumferences that differ between sites. There is a significant difference between sites with a probality of < 0.0001.

The Nakele site (1.44 m) has the highest girths than the other sites Gnarkèradouo (1.15 m) and Assoum 2 (1.26 m).

Fig. 2. Shea woods and park

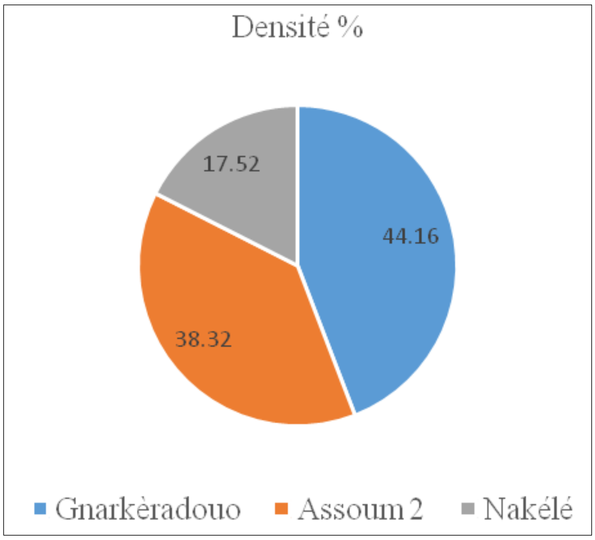

Fig. 3. Density of shea trees per hectare

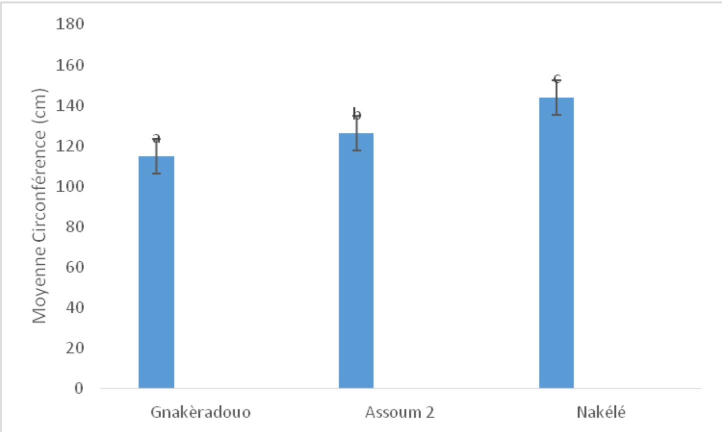

Fig. 4. Circumference of shea trees on the sites

3.3 Description of the Pits

3.3.1 The gnarkeradouo site

The Gnarkeradouo pit with coordinates (9°10'37" N and 3°6'15" W) and elevation 285 m, presented two horizons with a major induration constraint located at less than 60 cm depth and the low water table. These soils are gravelly with a sandy-silty texture with less than 10 percent clay. The coarse elements at 75 p.c. are composed of 80 p.c. of quartz, 20 p.c. of concretions and nodules. The surface horizon is 30 cm thick with a dark coloration of 5YR 3/1, it is humid and humusy. The structure is polyhedral. A strong biological activity exists by numerous roots of diameter going from millimeter to centimeter with a subhorizontal orientation. The soil is not coherent and is very porous with pores of millimeter diameter. The high coarse element load seems to be the major constraint. The horizon is of type A11. The second horizon is about 30 cm thick and lies on the induration with a high load of coarse elements. Its color is ochre 5YR 4/6, with low biological activity (Fig. 4). The horizon is very moist and humus-like with a silty-sandy texture and less than 5 percent clay. The coarse elements are made up of 85 p.c. of large rounded quartz of centimetric to decimetric size and 15 p.c. of nodules. The structure is polyhedral and the soil is not coherent but very porous with centimetric diameters. Roots are few in number with a subhorizontal orientation of millimeter and centimeter diameters. The constraint is a high coarse element load, induration, and a slickness at 60 cm (Fig. 5). The horizon is of type A12. The soil is a plinthic leptosol.

Fig. 5. Soil pit with two horizons

Fig. 6. Soil pit with three horizon

3.3.2 The assoum 2 site

The pit at the Assoum 2 site is located at latitude 9°11'13'' N and 3°5'38'' W. The altitude is 275 m. The pit has an induration level of more than one and a half meters. It reveals three horizons with the same characteristics as the first one. The only difference is that the load of coarse elements is low. The transition zone between horizons is progressive. Here The karite woods are more robust and older. The water table is deeper and the clay content is higher (Fig. 6). This soil is Luvisol.

3.3.3 Doropo site

The third pit at Doropo (Nakélé) with geographical coordinates, presented a single horizon, with an induration level located at less than 30 cm depth, as well as the low level of the water table. This horizon is sandy with a high proportion of fine sand. The soil is shallow and gravelly at depth. Such soils are more favorable to hardy woody species and plants with fasciculated roots (Fig. 7). The soil is a fluvisol.

Fig. 7. Soil pit with one horizons

4. DISCUSSION

4.1 Characteristics of Shea Butter Park Sites

Most sites are in the immediate vicinity of villages, which facilitates access, protection and monitoring. However, proximity can threaten the parks for village extension projects, as is the case in Doropo in the village of Nakélé where an entire park has just been subdivided as part of the extension of the target village. Apart from the village of Nakélé, the other two sites are subject to special surveillance as properties of the respective village chiefs.

The density of trees observed on the 3 sites is higher in this study than anywhere else. On our study sites, the density of shea trees is 102, 223 and 153 trees/ha respectively at Gnarkeradouo, Assoum2 and Nakélé. In Benin, studies have shown that the density varies from 12 to 44 trees/ha in the department of Atacora [28], and from 6 to 7 trees/ha in the fields, forest and fallow according to the work of [29]. The work of [10] showed 24 trees/ha in Burkina. These values show that tree density is high at the study sites. However, studies [30] show that the density of shea trees was 230 trees/ha in the 1940. Of the three sites, it is the Nakélé site that has a density that exceeds this value of [30]. The density has now dropped to 11 trees/ha. Our results are therefore higher than those of [31]. The cultivation practices and the lack of control over the regeneration of shea trees for industrial plantations or even for domestication are the causes of this reduction in density. The reduction of fallow time also reduces the density of Karaites on the sites according to the work of [21], however, the study sites being close to the villages and properties of the village chiefs have the protection of bushfires and are on surveillance. This would explain the high densities we observed on the sites. In addition, it is necessary to use ANR to increase the density of shea trees according to the work of [32]. However, in the work of [32] they recommend that in this strategy of restoring shea parks, a density of 100 feet/ha is required, which is not the case in our study. The circumferences of shea trees at the study sites are 1.15 m, 1.26 m and 1.44 m respectively at Gnarkéradouo, Assoum2 and Nakélé. This is partly consistent with the work of [33] who observed 1.26 m in circumference in a park natural shea tree at Tengréla in northern Côte d'Ivoire. The work of [30] and [34] showed that the circumferences of shea trees varied from 0.28 to 3.14 m and the values found correspond to theirs as well as the work of [35] give tree circumferences that vary from 0.5 to 2.87 m and those of [36]. Authors have observed circumferences ranging from 1.17 m to 1.75 m [10]. The circumferences of shea trees differ from one author to another and could be explained by the method of measurement and especially by the age of the trees. Since these are natural trees, it would be very difficult to give the exact age of the adult plants.

4.2 Morphological Characteristics of Soils under Shea

The 3 sites have different morphological characteristics. The Gnarkèredouo site has a 253 shallow soil, with an induration at 52 cm. It is a silty soil with a sandy-silty texture. Similar textures were observed on a 0-30 cm horizon of a shea park in northeastern Benin by [36], while the other 2 sites Assoum 2 and Nakélé have rather sandy-clay textures thus favoring good drainage, which corroborates the results of [37] in Congo and [4] in Senegal. The one in Nakélé also has an induration. Of these 3 sites, Assoum 2 is the deepest and therefore with easier root penetration. The roots go down to more than 50 cm. Morphopedological characteristics observed on the sites give plinthic Leptosols, Luvisols and Fluvisols respectively at Gnakèradouo, Assoum 2 and Nakélé. These characteristics show soils.

5. CONCLUSION

At the end of this study, it should be noted that the shea industry in the Boukani region suffers from a lack of organization that does not allow actors to maximize the potential of the speculation. Today, it is imperative to regroup the actors in the target villages in order to increase their added value. This should be done from the collection of fruits under the trees to the transformation into a finished product in order to increase their income for their empowerment. The kilogram of the finished product is negotiated between 700 and 800 CFA francs, against 75 and 100 CFA francs per kilogram of the nut. The expansion of villages adjacent to the parks threatens the natural orchards. Therefore, the creation of industrial fields by improved species with high yields and laws to protect the natural parks are necessary.

The soils under the park are gravelly with a major constraint of induration at shallow depth. They are however favourable to the development of speculation.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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