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Assessment of the Lido terroir *Acacia senegal* (L.) Willd. gum site yield (rural district of Guéchémé): perspectives for animal feed in Niger

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Abstract
The aridity of the Sahel climate and anthropic activities constitute factors hampering the production of several legumin species. This study conducted in the rural district of Guéchémé aims at assessing the fruit yield of the A. senegal gum site of the village terroir of Lido. The methodology consisted in complete collections of fruit from randomly selected A. senegal trees. The grain and hull food values have been determined from samples analyzed at the biochemical laboratory. The results indicated that the average fruit production per A. senegal tree on the gum site varied from 9.86 ± 4.95 Kilograms, its average production per hectare was 1235.78 kilograms corresponding to 1530947 fruits. The average number of grains of 100 fruits was 311,1 ± 85,78 and the average weight of the grains contained in 100 fruits was 0.0303 ± 0.0072 Kilogram. The hulls of the fruits were richer on average (31.92 ± 42.48) than the grains (24.78 ± 38.59) in gross cellulose.
Implication of the results: *knowing the fruit production of A. senegal per tree and per hectare constitutes an interesting asset for the development of these products. Once we understand the food value of the hulls and grains as well as their biochemical composition, it will certainly have a significant implication for animal feed in the Sahel region.*
Key words*: yield, Acacia senegal, Guéchémé, Lido, Niger*

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I. Introduction

Rain forests constitute an immense reservoir of biological resources. They play a fundamental role in the fulfillment of numerous needs of the populations[1]. These ecosystems supply populations with resources used for diverse purposes: feeding, handwork, medical and spiritual purposes[2,3]. In Africa and particularly in the Sahel region, the woody, shrubby and arborescent vegetation plays a tremendous role in maintaining the socioeconomic balance of the populations. In fact, this spontaneous flora serves as food[4], medical supplies[5], construction material, domestic tools, energy sources[6] and contributes to diversify the sources of income[7]. In addition to their ecological and economic functions, they also have social and cultural values. Sources of feed, the leaves, the flowers and the fruits constitute an important supplement for cattle feed and for part of the wildlife[8]. In the dry season, woody settlements supply cows, sheep and goats with protein and vitamin supplements indispensable for their survival[8,10]. Through this ecological function of trees, arborescent or shrubby stands of arid or semi-arid areas rank first in terms of cattle feed supplement. These are trees or shrubs with multiple uses in various cattle breeding systems or farming and forestry in tropical regions. Some of these intervene in the protection of the soil against erosion. Other species, including *Acacia senegal*, play an important socioeconomic role for the populations of arid areas. Commonly called the gum tree, this species is known by several authors as forage species. Recent results of studies showed that the cloves, the grains, the leaves are regularly used during the dry season in the breeding of sheep, goats, and camels[11,12].

However, anthropic actions such as the abusive cutting of branches for cattle feed dangerously reduce the density of the species settlements today as well as the fruit production which remains very little known on the ground. Studies in the region and in Niger focused on the assessment of the fruit yield of species like

Adansonia digitata L. in Senegal[13], *Parkia biglobosa* in Niger[14] *Bombax costatum* Pellegr. & Vuillet in Burkina Fasso[15], and *Neocarya macrophylla* (Sabine) Pranc in Niger[16]. In Niger, despite the socioeconomic, farming and agroecological importance of the *Acacia senegal* , the fruit yield of natural settlements and that of the gum sites is unknown. Hence the importance of this study whose objectives are: (i) assessing the fruit yield of *Acacia senegal* of the gum site of the Lido terroir in the rural district of Guéchémé and (ii) determining the chemical composition of the fruits for cattle feeding perspective in Niger.

II. Materials and methods

2.1. Area of the study

This study was conducted in the village terroir of Lido, located in the rural district of Guéchémé (**Fig. 1**) one kilometer north of the village of Lido. The gum of site of Lido has been one of the target sites of a reforestation project since 2006 for the boosting of gum production and carbon sequestration. This project was registered at the secretariat of the Mechanism of Clean Development (MCD) for the research of carbon credits with the support of the World Bank through the Community Action Program (PAC in French). The climate is of Sahelian type, featured by unequal rainfall distribution in time and space. We mainly have two seasons:

- ✓ A long dry season that last eight (08) months, from October to May and that is subdivided into two distinct periods: a cold and dry period (November - February) and a dry and hot period (March – May);
- ✓ A rainy season from June to September (three months).

There are three types of soil: sandy loam, hydromorphic, and lateritic,

The vegetation is much diversified both in terms of woody and herbaceous stands. The relics of contracted forest formations are at risk of extinction due to abusive cutting for wood and service exploitation. Besides the small fauna, the big fauna is almost nonexistent because of the disappearance of its habitat via the effects of deforestation.

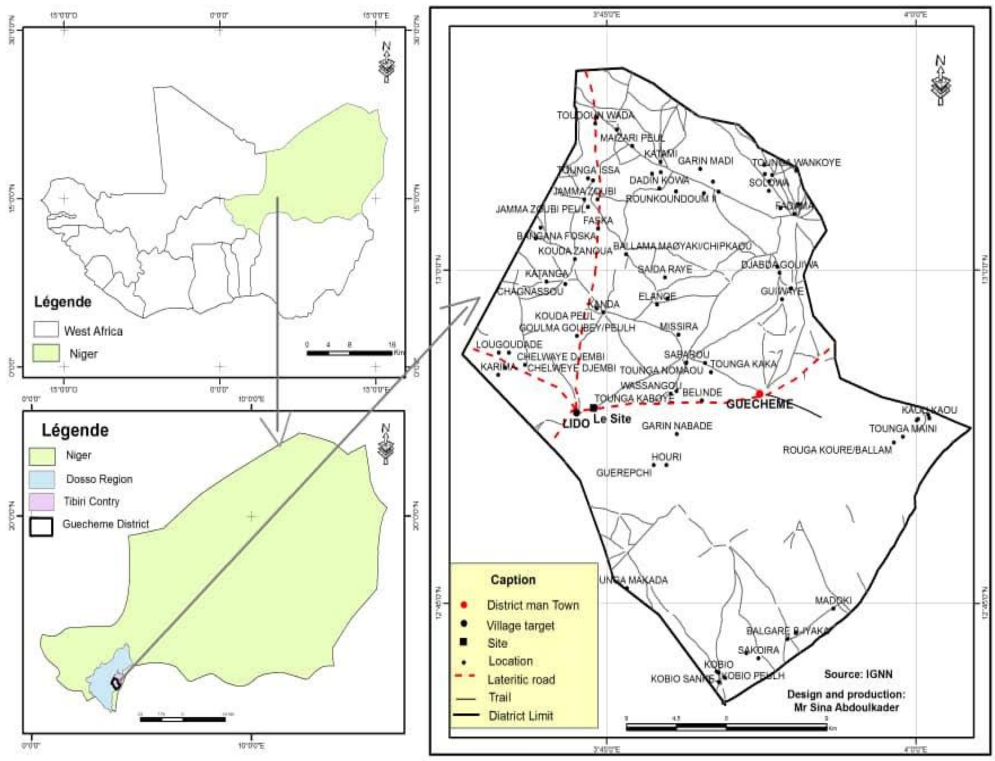

Figure 1: Geolocation of the rural district of Guéchémé

2.2. Methodology

2.2.1. Sampling of the trees for fruit collection

To collect the dry and ripe fruits, fifty (50) trees of *Acacia seneagal* have randomly been selected and georeferenced across the entire five (05) plantation blocks subdivided in terms of plantation years (2006, 2007, 2008, 2009, and 2011). The selection criteria based on direct observation took into account the plant's health condition, the presence of fruits and the

distance between plants (20 meters). The plants displaying signs of anthropic actions such as branch cutting or trimming were excluded from the sample selection process. Considering the presence of hook-like thorns, the fruit collection was conducted in a complete manner using two to four-meter high hooked perches. The fruits picked were collected in 100-kilogram sacks, then weighed by means of spring scales. (Figure 2).

Figure 2: Collection of *A. senegal* fruits: a) productive plants; b) plants with ripe fruits; c) lifting fruits using perches; d) weighing fruits in 100-kilogram sacks (Sina, 2020).

2.2.2. Measured parameters

To assess the fruit production of the *A. senegal*, the following biophysical parameters were determined for each selected *A. senegal* plant:

(i) the diameter 20 centimeters off the ground ; (ii) the total height of the plant ; (iv) the average crown diameter (v) the total number of fruits ; (vi) the total weight of fruits ; the weight of 100 fruits ; (vii) the number of grains of 100 fruits ; (vii) the weight of grains of 100 fruits ; (vii) the length and width of a sample of 50 fruits randomly selected. These parameters permitted to determine the average *A. senegal* fruit production to establish the equations needed to determine the average fruit production per plant, the relationship between the dendrometric parameters (basal diameter, plant height and average crown diameter) and the descriptive parameters of the fruits (fruit weight, fruit length, fruit width, and fruit number)

2.3. Data processing and analysis

The average fruit and grain production per plant of *A. senegal* is computed by calculating the average production of a plant (Pu) based on the formula:

$$\mathrm{Pu} = \frac{\sum \mathrm{Pi}}{\mathrm{N}}$$

where Pi is the quantity of harvested fruits from the plant i and N the total number of plants from which the fruits have been collected.

Going from this formula and knowing the density of *A. senegal* (D) per hectare, the fruit production of the species within a hectare of plantation (PT) is estimated.

$$PT = Pu*D$$

$$D = \frac{\sum ni}{10000m^2}$$

ni = Number of *A. senegal* per inventoried plot and 10 000 m² is the area of a hectare

Therefore $$PT = \frac{\sum Pi}{N} \times \frac{\sum ni}{10000m^2}$$

This formula has been used par authors such as Kouyaté (2005) to assess the yield of *Detarium microcarpum* Guill. & Perr. Per hectare in Mali, Sawadogo *and al*. (2018) to determine allometric models of prediction of the fruit production of the *Senegalia macrostachya* (Reichenb. ex DC. Kyal & Boatwr) in Burkina Faso.

The correlations and linear regression curves between the descriptive parameters of fruit yield (length of fruits, width of fruits weight of fruits and number of fruits) and the dendrometric parameters (trunk diameter 20 centimeters off the ground, average crown diameter, the height) have been determined using the software Minitab 14. The Ficher's test has been used to compare the averages.

III. Results

3.1. Fruit production

The average production of *A. senegal* per plant was 9.86 ± 4.95 Kilograms, corresponding to 12,215 ± 5.622,47 fruits. The average production per hectare was 1235.78 kilograms corresponding to 1,530,947 fruits. The average number of grains of 100 fruits was 311.1 ± 85.78 and the average weight of grains contained in 100 fruits was 0.0303 ± 0.0072 Kilogram.

3.2. Correlation between fruit morphologic descriptors

The length and width of the fruits were significantly correlated (P > 0,000). The coefficient of correlation R^2 = 0.391 and adjusted R^2 was 0.388 (figure 4).

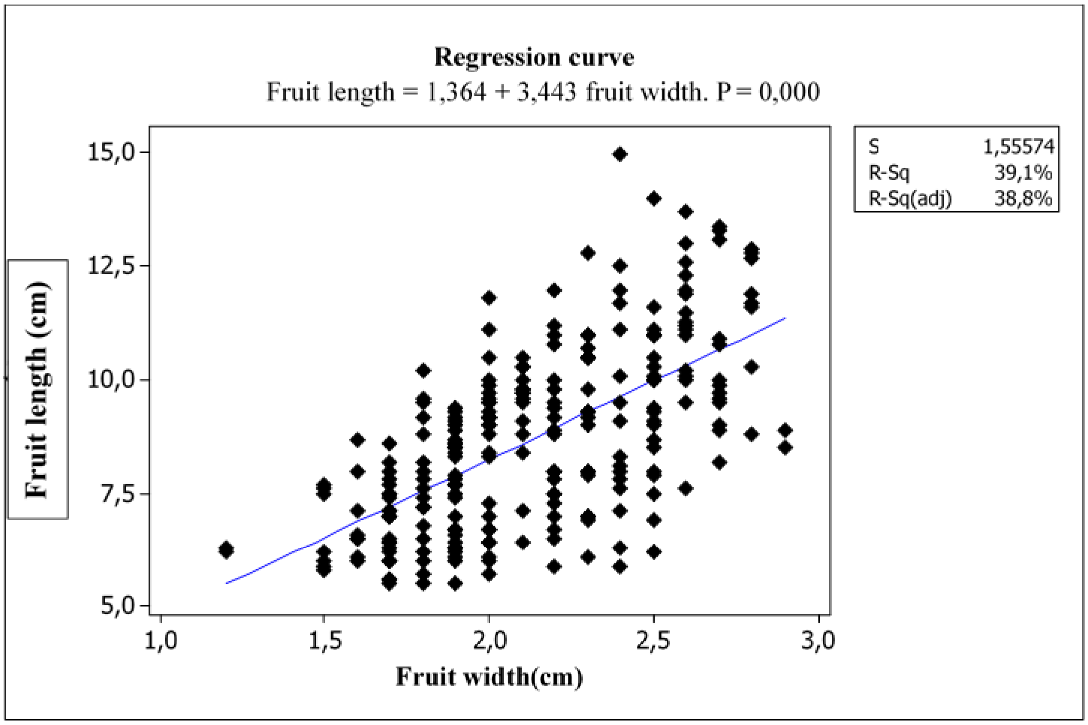

Figure 4: Regression between *A. senegal* fruit length and width

3.3. Variation between the morphological descriptors of fruits

The average variation between the length and width of fruits of *A. senegal* per block of plantation year is given in Table 1. The Ficher's test indicates that this variation is highly significant (P = 0,000) with all the plantation years.

Table 1: Variation of average fruit length and width

Plantation blocks/years	Average fruit length (cm)	CV (%)	Average fruit width (cm)	CV (%)
2006	50 ± 7,42	14,84	50 ± 1,84	3,68
2007	50 ± 8,87	17,74	50 ± 1,91	3,82
2008	50 ± 10,3	20,6	50 ± 2,5	5
2010	50 ± 10,31	20,62	50 ± 2,48	4,96
2011	50 ± 6,59	13,18	50 ± 2,41	4,82
	P* = 0,000		P* = 0,000	

3.4. Correlation between dendrometric parameters and fruit production

The results in figure 5 indicate that the correlation between average crown diameter and fruit production is highly significant (P = 0,000) with a the coefficient of determination) R^2 = 0,832 and adjusted R^2 equals 0,825. The correlation between *A. senegal* plant heights and their yield is highly significant as well (P = 0,000). The coefficient of determination R^2 = 0,816 and adjusted R^2 equals 0,808 (figure 5b). The height and diameter of A. *senegal* plants are also correlated (figure 5c). This correlation is highly significant, too (P = 0,000). The coefficient of determination R^2 = 0,753 and adjusted R^2 equals 0,748. The results on fruit yield indicate that the weight of 100 fruits and the weight of the grains of 100 fruits are positively correlated. This correlation is significant (p =0,000). The coefficient of determination R^2 = 0,622 and adjusted R^2 is 0,06 (figure 5d).

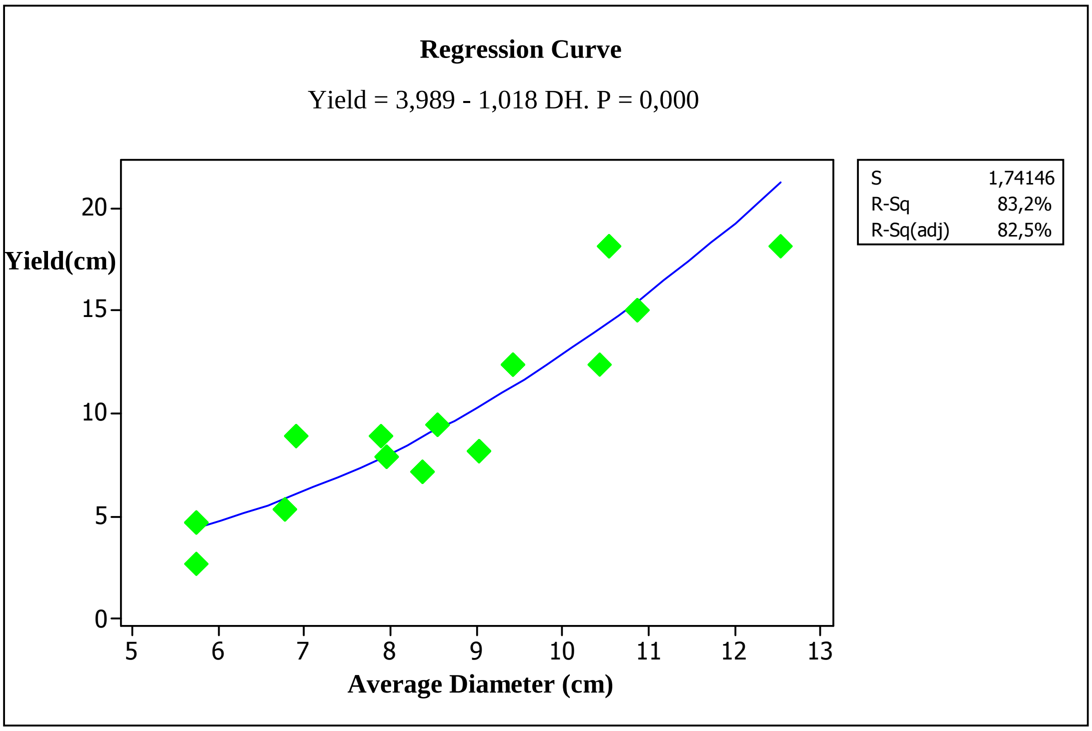

Figure 5a: Regression between average crown diameter and A. *senegal* fruit yield

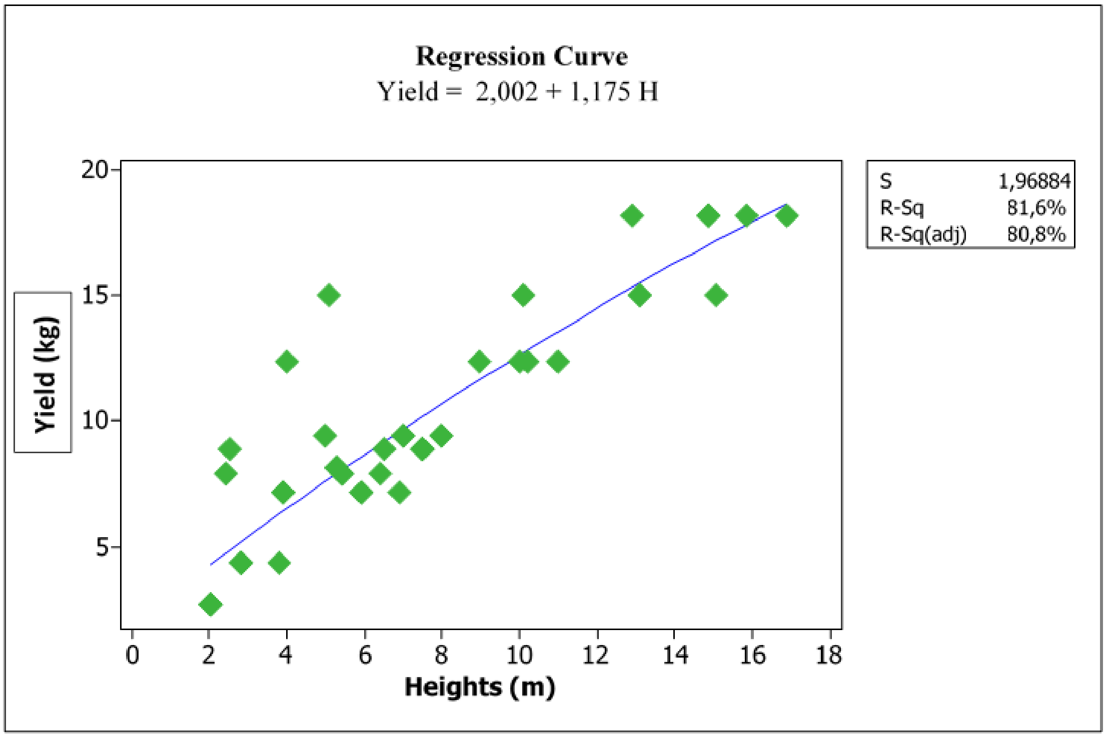

Figure 5b: Regression between height and *A. senegal* fruit yield

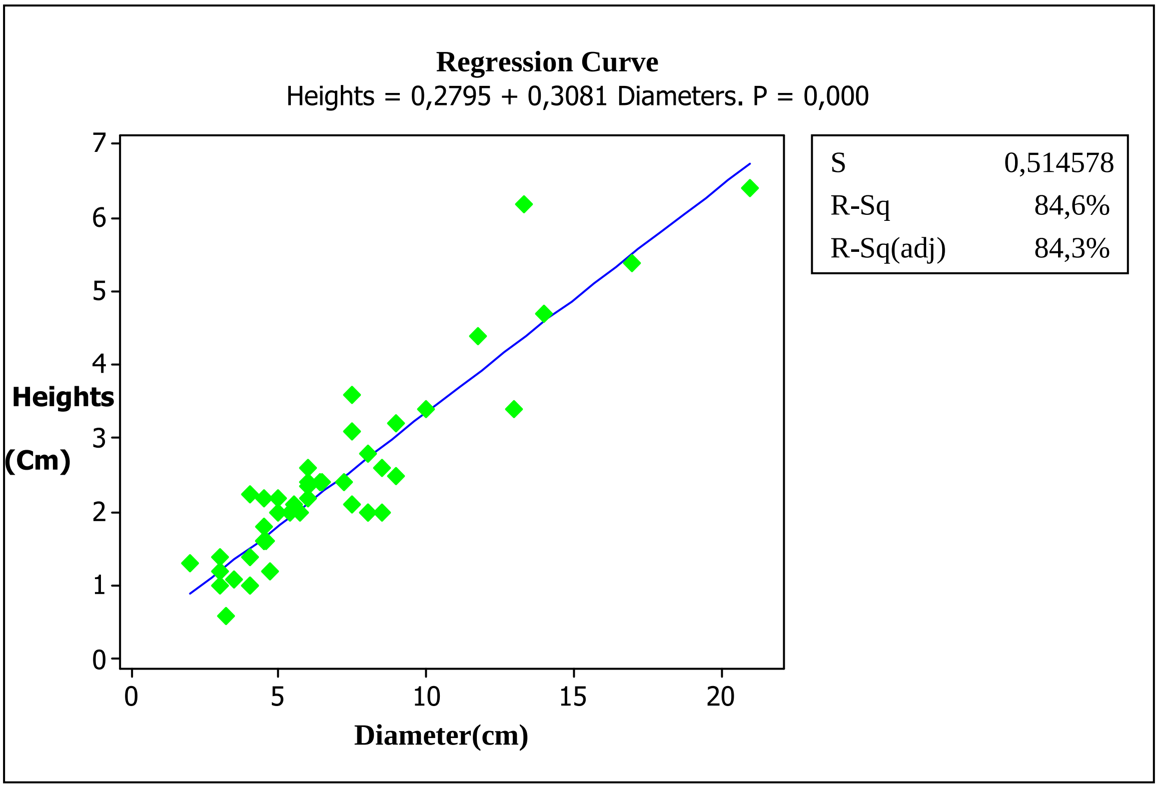

Figure 5c: Regression between diameter and height of *A. senegal* plants

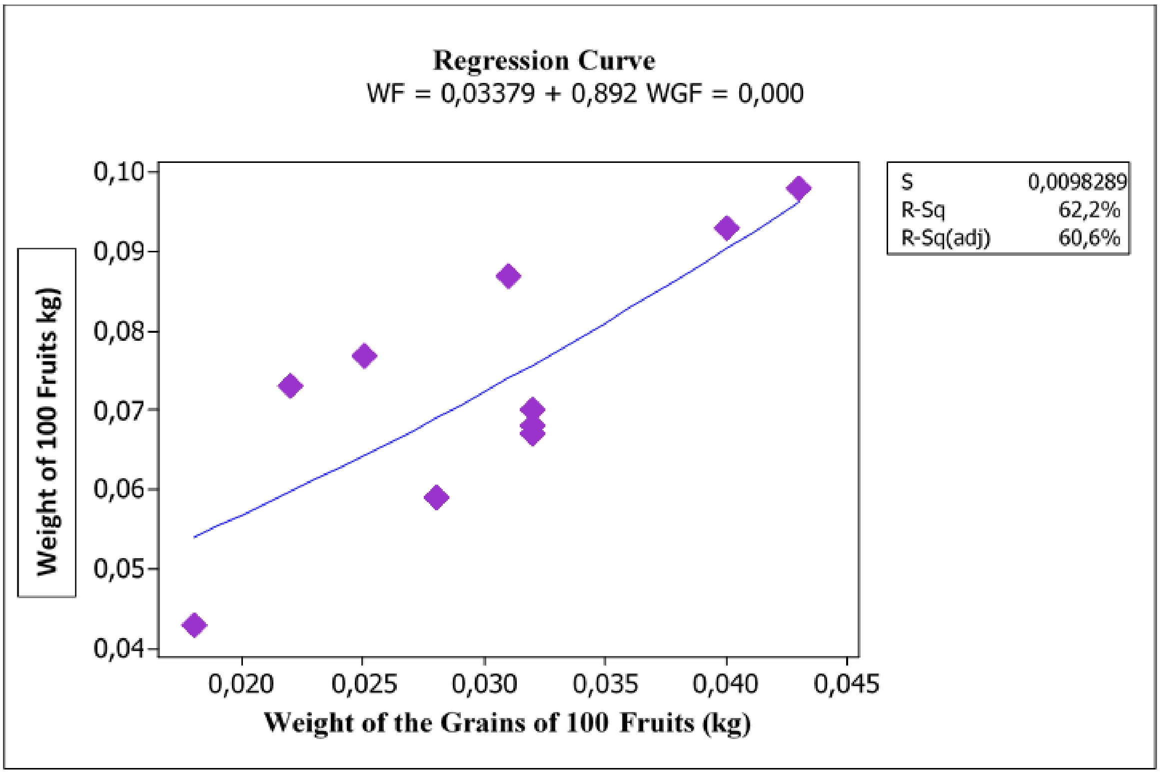

Figure 5 d: Regressions between the weight of 100 fruits and the weight of 100 grains contained in 100 fruits

3.5. Cattle feed values of the grains and fruit hulls

The results in table 2 illustrate the chemical composition of the fruits (grains + hulls) of *A. senegal*. These results indicate that on average, the quantity of dry matter is more abundant in the grains (figure 6a) and the hulls (figure 6b) than the other chemical compounds. The comparative analysis shows that the gross cellulose is present up to 15.8% in the grains versus 54.2% in the fruit hulls. The mineral matter, though weak, is at 4.21% in the grains versus 6.02% in the hulls. The proteins and lipids are also present in the grains and the hulls. Their values are respectively 5.67% and 0.6% versus 4,92% and 2.18%. The quantity of nitrogen is present to a total value of 1.1%.

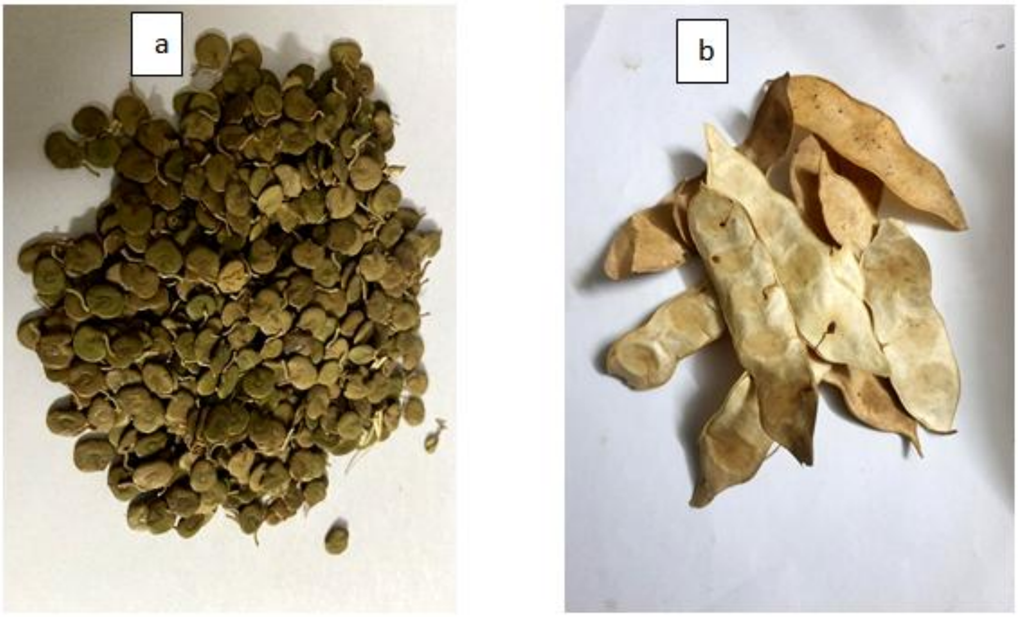

Figure 6: Grains (a) and hulls (b) of *Acacia senegal* (Sina, 2020)

Table 2: Cattle feed values of *A. senegal*

	Averages					
Fruits	Dry matter (%)	Minerals (%)	Proteins (%)	Fats (%)	Gross cellulose (%)	Nitrogen (%)
Grains	93,3	4,21	5,67	4,92	15,8	0,91
Hulls	96,62	6,02	0,6	2,18	54,2	0,10
Total	189,92	10,23	6,27	7,1	70	1,10

IV. Discussion

Although lower, the Arabic gum production constitutes the first objective of *A. senegal* planters. Yet, this species offers many advantages to populations in the Sahel region. Among the expressed advantages, fruit and grain production ranks last. Nonetheless, this indicator constitutes a key parameter for an efficient and sustainable management of the exploitation of a forest resource in a context of climate variability and stronger anthropization. This study permitted to show the importance of A. *senegal* fruit production on the gum site of the Lido terroir. The results on the quantity of fruits produced per plant of *A. senegal* in this study are more significant than those found[17] on the fruit production of *Senegalia macrostachya* (Reichenb. ex DC. Kyal & Boatwr) in the savannas and fallow of north-south Burkina Faso. This difference is probably linked to several factors, including the type of ecosystem, edaphic conditions (soil types) in which the species develop, climate conditions (droughts) and the impact of anthropic activities on the dynamics of species (abusive cutting, overgrazing, forest fires, the advancement of the farming front) as well as the species given the fact that we do not have the same species. The Acacias of the terroir of Lido develop in artificial plantation sites that are protected by the populations. Some factors of anthropic pressure and wondering cattle impacting the fruit production of the species can be controlled by management committees. Several other parameters compromise the fruit production of these species such as repeated clove attacks during the fruitage by organic pests. These insects cause enormous damage to this species during the phenological phase of the fruitage because thousands of cloves deteriorate during this period. Our results are also more significant than those found by Laouali *and al*. (2015)[14] on *Prosopis africana* in southeast of Niger. This difference of production is due to the fact that the legumin species (*Prosopis africana*) produces fewer fruits than the *A. senegal*. Additionally, it was revealed enormous clove attacks by insects during the phenological phase of fruitage by these authors. Results below those found in this study have also been obtained by other researchers on *Adansonia digitata* L. by Sanogo *and al*. (2013 and 2015)[13,18] in Senegal and on *Detarium microcarpum* in Mali (Kouaté *and al*., 2006)[19]. The significant correlation between the fruit production and the average crown diameter matches results found by other authors[9,13,14,19,20]. These results indicate that the 20-centimeter diameter off the ground for shrubs such as *A. senegal* constitutes a good indicator permitting to predict the fruit production of forest species in the Sahel region, just like for the 1.30-meter diameter used by other authors. The length of fruits correlated because the growth in length and width of fruits constitutes the ultimate morphological descriptor that raises the quantity and size of the fruits. The results of the chemical composition of the fruits show that the cloves of *A. senegal* are foremost richer in cellulose compared to the energetic matter. The hulls of the fruits are on average richer (31.92 ± 42.48) than the grains (24.78 ± 38.59). Results higher than those obtained in this study have been found by Ickowicz *and al*. (2005)[21]. These authors showed that the cloves of this species are richer in nitrogen and poorer in energetic matter. In Chad, results on the variability of the food value based on the season from a sampling performed at different dates did not indicate a significant effect[21]. The differences observed based on our results can be linked to the genetic variability or pedological, climatic, sociocultural, and anthropological conditions of the areas in which the plants of the species develop.

V. Conclusion

The assessment of fruit production of forest species in the Sahel region constitutes a less explored field. Through this study, the *Acacia senegal* fruit production has been assessed. The results obtained show that the production of this species on the gum site is significant but it is subject to variations due to caterpillar attacks during the phenological phase. To monitoring of this fruit production in order to improve it, entomological studies must be undertaken to identify the different insects that attack this species during its fruitage phase. Separately, it might be interesting to collect data over several years to think out the allometric equations that permit to predict the production of this species whether on plantation sites or in the natural milieu. The absence of data on the monetary value of the fruits and grains must be fulfilled for the development of ecosystem services of the species. The results of this study pave the way to perspectives for the domestication of the species. To succeed this domestication, it is important to grant the different management committees of the sites tools of appraisal based of simple measurements.

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