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### RESEARCH ARTICLE

## INFLUENCE OF CASSIA SIEBERIANA DC (SIEBER'S CASSIA, FABACEAE) ON SOIL PHYSICOCHEMICAL PROPERTIES IN FANDENE, SENEGAL

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### Abstract

Senegal is facing increasing soil degradation, particularly in arid and semi-arid zones. This degradation is largely due to climate change and inappropriate farming practices, which have led to a decline in soil fertility and lower agricultural productivity. To enhance soil fertility, legumes such as Cassia sieberiana DC are considered a potential solution. Although these species are socio-economically, ecologically, and medicinally important, research on their specific impacts on soil fertility remains limited and inconsistent. This study aims to assess the influence of *C. sieberiana* on soil physicochemical properties. Soil samples were collected from natural stands of *C. sieberiana* in Fandene across three diameter classes, both under and above the crown, at two depths. Soil physicochemical parameters were assessed. The results indicated that the soil texture beneath *C. sieberiana* was sandy loam. The results showed significant effects of diameter class, radius, depth, and interactions between class and depth, and between radius and depth, on carbon (C), organic matter (OM), and nitrogen (N). However, pH varied with depth. Electrical conductivity (EC) varied with depth and interactions. The results showed that OC and OM contents were higher at 2/3R of the crown, in diameter class C2 and at a depth of 0-20cm. These results underline the importance of sustainably managing these trees in agroforestry systems to mitigate soil degradation and improve agricultural productivity. However, it would be interesting to study the effect of the species on soil cation exchange capacity, and minerals such as calcium, potassium, magnesium, sodium and sulfur.

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### Introduction:-

*Cassia sieberiana* DC., a small tree found in the Sudano-Guinean and Sudanese savannahs, belonging to the Caesalpinioideae subfamily (Fabaceae family)<sup>1</sup>, is 8 to 10m tall with a short trunk. It is typically branched near the base and features flexible, drooping branches. Its bark is brownish and turns blackish with age. The leaves are compound, paripinnate with 6 to 10 pairs of leaflets, and opposite, alternate, dark green in colour, oval or oblong, with a rounded base and a wedge-shaped tip. Its flowers are golden yellow and appear in very long, drooping

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terminal racemes (25 to 40cm). From March to May, large, beautiful clusters fully cover the tree. The fruits are long cylindrical pods, 40-60 cm long and 10-15mm in diameter, straight, dark brown or blackish, and persist on the tree for a long time<sup>2,3</sup>. Its seeds vary in colour from greenish brown to dark brown with a smooth surface and may have small brightly coloured stripes on the outer surface<sup>4</sup>. *C. sieberiana* is a multi-purpose species<sup>2</sup>. The leaves, roots and pods of *C. sieberiana* are commonly used in traditional medicine<sup>5</sup>. The species is certainly one of the most cited plants for its purgative and diuretic properties<sup>6</sup>. In Uganda, powder from various plant parts is used to treat toothache. Mixed with butter, it is used to treat skin diseases. Extracts from *C. sieberiana* leaves are very effective at killing the *Plasmodium falciparum* parasite, one of the most dangerous human pathogens, responsible for the extremely severe forms of malaria<sup>7</sup>. *C. sieberiana* has a high content of calcium oxalate crystals in addition to other phytochemical compounds such as quercitrin, isoquercitrin and rheine, anthraquinones, flavonoids, saponins, steroids, terpenoids, tannins, cardiac glycosides, and reducing sugars. The triterpenoids and polyphenols (flavonoids and tannins) found in the roots of *C. sieberiana* are responsible for its antiparasitic effect<sup>8</sup>. In Benin, the twigs are used to treat sleeping sickness, etc<sup>9</sup>. *C. sieberiana* leaf accelerates banana ripening<sup>10</sup>.

The species thrives in moist, well-drained soils in forest galleries in regions that receive at least 500mm of annual rainfall. However, it can grow as bushes on lateritic or arid sites<sup>2</sup>. It can be planted individually on farms, with a minimum spacing of four metres. The interaction of trees and shrubs with the soil can influence its physical, chemical, and biological properties, thereby affecting its structure, fertility, and ability to provide ecosystem services. Trees increase soil cover through litter and pruning residues, create partially permeable hedgerows, especially for wind protection. They facilitate the gradual formation of terraces through the accumulation of soil upstream of hedges, stabilise soil structures through their root systems, and reduce runoff<sup>11</sup>. Plant growth is strongly influenced by soil structure, but the reverse is negligible<sup>12</sup>. Soil fertility encompasses the biological, physical, and chemical properties of soil and represents its ability to maintain favourable conditions for sustainable plant growth. Many authors have reported increases in carbon (C), nitrogen (N), cations, and assimilable phosphorus in the soil beneath tree canopies, which constitute islands of fertility. In the savannah, pH is a parameter that plant roots can directly modify through multiple processes, including mainly root respiration, the excretion of root substances from trees and crops, and the release of H<sup>+</sup> and OH<sup>-</sup> to compensate for a net excess of cations or anions<sup>13,14</sup>. Findings by Dalila confirm that crops sown on soils formed under tree cover, compared with those on uncovered control plots, highlight the role of trees in improving soil fertility<sup>15</sup>.

Soil nutrient concentrations as a function of distance from trees indicate significantly higher levels of carbon, nitrogen, phosphorus and potassium beneath tree canopies compared to soil outside the canopy<sup>16</sup>. Generally, the levels of these elements decline with increasing distance from the tree and with soil depth<sup>17</sup>. It is widely accepted that green manures, such as legumes, provide nutrients to the soil, thereby boosting agricultural soil fertility and productivity by improving chemical properties, including carbon and nitrogen levels, and crop yields<sup>18,19</sup>. Additionally, they can provide shelter for soil, plants, and livestock, with the subsequent benefit of organic matter and soil nutrients<sup>20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30</sup>. The contribution of organic matter from biomass produced by agroforestry systems affects nutrient recycling. However, some species emit substances that can affect weed and crop development by depleting soil resources, as is the case with *Eucalyptus*<sup>31</sup>. Although the benefits of *C. sieberiana* are recognised, documentation of the species' impact on the physico-chemical characteristics of soils remains limited and fragmented<sup>25</sup>, unlike for other species such as *F. albida*, *V. paradoxa* and *P. biglobosa*. However, the species is a non-nodulating legume. The objective of this study is to evaluate the influence of *Sieber's* cassia on soil physicochemical parameters. A research question that could arise from a study is: Do diameter class (factor 1) and distance to the tree (factor 2) influence soil parameters at depths of 0-20cm and 20-40cm ?

## Material and Methods:-

### Presentation of the study area:-

The study was conducted in the municipality of Fandene, in the Thies region (14° 27' N, 16° 55' W), characterised by a sudano-sahelian climate with a long dry season and a rainy season lasting just over three months (Figure 1). The region is influenced by maritime trade winds and the harmattan<sup>32</sup>. The soils are ferruginous and hydromorphic. The vegetation consists mainly of degraded shrub savannah, with monospecific stands of *Acacia seyal*, *Adansonia digitata*, *Faidherbia albida* and *Borassus aethiopum*. Rainfed agriculture is the main activity, practised by almost the entire population.

**Tree selection:-**

An inventory was conducted in the wooded parks of *C. sieberiana*. Trees with a diameter of  $\geq 5$ cm were measured using a forest compass. The dendrometric data were recorded, and the trees were classified by size into three (03) classes: C1 (5-15cm), C2 (15-25cm), and C3 ( $>25$ cm). For each diameter class, three (03) individuals were randomly selected as replicates, for a total of nine (09). These individuals were geolocated using a GPS and then marked with paint. For each tree, the crown radius was measured using a tape measure. A digital camera was used to visually document the environment, plant specimens and soil conditions. Soil sampling was carried out at four locations of the tree radius (R) : 1/3R, 2/3R and 3/3R, as well as outside the crown considered as the control (T). Soil samples were collected using an auger at two (02) depths: 0-20cm and 20-40cm. The total number of soil samples was 72, with 36 sampling points (3 diameters x 3 replicates x 4 distances to the tree x 2 depths). The samples were then placed in bags and sent to the soil science laboratory at the High National School of Agriculture (ENSA) in Thies, Senegal, for complete analysis.

**Physicochemical analysis of soil samples:-**

Measurements were taken of pH, electrical conductivity (EC), particle-size distribution (sand, clay, silt), organic carbon (OC), and N. The samples were air-dried and then sieved to 2mm. Particle size analysis was performed using the Robinson pipette method. Soil pH was determined potentiometrically using a pH meter in an aqueous extract at a soil-to-water ratio of 1/2.5. Electrical conductivity was determined using a conductivity meter. The organic matter content was assessed using the modified Anne method (spectrophotometry). The carbon content was measured using a spectrophotometer at 600nm.

**Data processing:-**

The physicochemical data were subjected to a two-factor analysis of variance. The 36 observations at 0-20cm and at 20-40cm were analysed separately using XLSTAT 2013. The Tuckey test was performed to compare the means. The data were also used to develop the textural triangle using the GEPPA sigales 2020 database.

**Results:-****Physical characteristics of soils under *C. sieberiana*:-**

The analysis of variance showed no significant differences between treatments (classes, rays) for almost all variables studied. However, a significant interaction effect between C2 and C3 on total sand content was observed (Table 1). The highest silt and sand contents were found in class C2. Clay content was lower in all classes (2.9%, 2.3%, and 1.1%). The texture triangle for the different samples showed sandy loam texture under and outside the canopy.

**Chemical characteristics of soils under *C. sieberiana*:-****Variations in soil pH and electrical conductivity:-**

Table II presents the analysis of variance for soil pH and electrical conductivity. A significant effect of diameter classes on pH was observed. The highest pH values were found in C1, and C3 had the lowest pH. There was no significant difference in pH levels between sampling position from the crown radii and the sampling depths. Table II shows that diameter classes and crown radius do not affect EC.

**Variations in soil organic carbon and total nitrogen content:-**

Organic carbon, OM, N contents and C/N ratio are recorded in Table III. The diameter class affected all these parameters, and the crown radius influenced both OC, OM, N, and C/N. The highest OC (1%), OM (2%), and N (0.1%) contents, as well as C/N, were reported in C2 compared with C1 and C3. Organic carbon (1.87%) and OM (0.93%) contents were higher at 0-20cm depth. At 20-40cm, the OC and OM contents were 0.86% and 0.43%, respectively. Nitrogen and the C/N ratio followed the same trend as OC across sampling depths. Organic carbon, and OM were also much higher at 2/3R and 1/3R, followed by 3/3R. The control (outside the canopy) recorded the lowest OC and OM values. However, N levels were higher outside the crown (0.09%) of *C. sieberiana* than under the crown (0.07%). At 3/3R, the N level was 0.08%, and at 1/3R and 2/3R, it was 0.06% N.

**Influence of interactions on soil physicochemical parameters:-**

Variations in chemical parameters following interactions between diameter classes, crown radii and sampling depth were detected. For each diameter class, significant variations were observed with sampling depth. The pH was generally higher at the surface (0-20cm) than at depth (20-40cm), particularly in class C2, whereas it remained constant in C3. Electrical conductivity was higher in the surface layer, particularly at 1/3R. At 2/3R within the 0-20cm depth range, EC peaked at 54.189 $\mu$ S/cm. Nitrogen showed a similar pattern, with elevated levels at the surface

that declined with increasing depth. The C/N ratio declined slightly as crown radii and depth increased, indicating changes in C and N concentrations. For class C1, the values of chemical parameters were moderate at 1/3R. At 2/3R, EC, and OC increased markedly. These values decreased at 3/3R. For C2, EC, and OC concentrations were higher at 2/3R. For C3, variations in chemical properties as a function of crown radii were less pronounced, but an overall decrease in OC, OM and N levels was observed at higher radii.

List of tables:-

**Table I: Analysis of variance of the different soil particle size fractions**

	Clay	Silt	Sand
<b>Diameter classes</b>	<b>%</b>		
C1	2,94 <sup>a</sup>	26,61 <sup>a</sup>	70,44 <sup>ab</sup>
C2	2,27 <sup>a</sup>	29,75 <sup>a</sup>	76,98 <sup>b</sup>
C3	1,08 <sup>a</sup>	21,93 <sup>a</sup>	67,97 <sup>a</sup>
<b>Pr &gt; F</b>	<b>0,346</b>	<b>0,065</b>	<b>0,043</b>
<b>Crown radii</b>			
1/3R	3,396 <sup>a</sup>	24,695 <sup>a</sup>	71,909 <sup>a</sup>
2/3R	1,899 <sup>a</sup>	25,131 <sup>a</sup>	72,970 <sup>a</sup>
3/3R	0,854 <sup>a</sup>	28,718 <sup>a</sup>	70,428 <sup>a</sup>
T	2,242 <sup>a</sup>	25,872 <sup>a</sup>	71,886 <sup>a</sup>
<b>Pr &gt; F</b>	<b>0,401</b>	<b>0,741</b>	<b>0,953</b>

**Table II: Analysis of variance of soil pH and electrical conductivity**

	pH	EC ( $\mu\text{s}/\text{Cm}$ )
<b>Diameter classes</b>		
C1	5,68 <sup>a</sup>	27,8 <sup>a</sup>
C2	5,59 <sup>ab</sup>	33,41 <sup>a</sup>
C3	5,43 <sup>b</sup>	28,19 <sup>a</sup>
<b>Pr &gt; F</b>	<b>0,01</b>	<b>0,63</b>
<b>Crown radii</b>		
1/3R	5,49 <sup>a</sup>	27,49 <sup>a</sup>
2/3R	5,59 <sup>a</sup>	36,38 <sup>a</sup>
3/3R	5,55 <sup>a</sup>	26,72 <sup>a</sup>
<b>Pr &gt; F</b>	<b>0,456</b>	<b>0,558</b>

The values are means. Letters depict a significant difference between means within columns at the 5% level.

**Table III: Analysis of variance of organic matter, carbon and total nitrogen contents in soils**

	OC (%)	OM (%)	N (%)	C/N
<b>Diameter classes</b>				
C1	0,63 <sup>b</sup>	1,27 <sup>b</sup>	0,07 <sup>b</sup>	8,79 <sup>a</sup>
C2	1,00 <sup>a</sup>	2,00 <sup>a</sup>	0,10 <sup>a</sup>	9,564 <sup>a</sup>
C3	0,41 <sup>b</sup>	0,82 <sup>b</sup>	0,050 <sup>b</sup>	7,24 <sup>b</sup>
<b>Pr &gt; F</b>	<b>0,01</b>	<b>0,03</b>	<b>0,001</b>	<b>&lt; 0,0001</b>
<b>Crown radii</b>				
1/3R	0,77 <sup>b</sup>	1,77 <sup>b</sup>	0,06 <sup>a</sup>	8,79 <sup>a</sup>
2/3R	0,89 <sup>b</sup>	1,53 <sup>b</sup>	0,06 <sup>a</sup>	8,81 <sup>a</sup>
3/3R	0,56 <sup>a</sup>	1,13 <sup>a</sup>	0,08 <sup>b</sup>	8,14 <sup>a</sup>
T	0,51 <sup>a</sup>	1,02 <sup>a</sup>	0,09 <sup>b</sup>	8,39 <sup>a</sup>
<b>Pr &gt; F</b>	<b>0,005</b>	<b>0,005</b>	<b>0,005</b>	<b>0,47</b>

The values are means. Letters depict a significant difference between means within columns at the 5% level.

#### List of figures:-

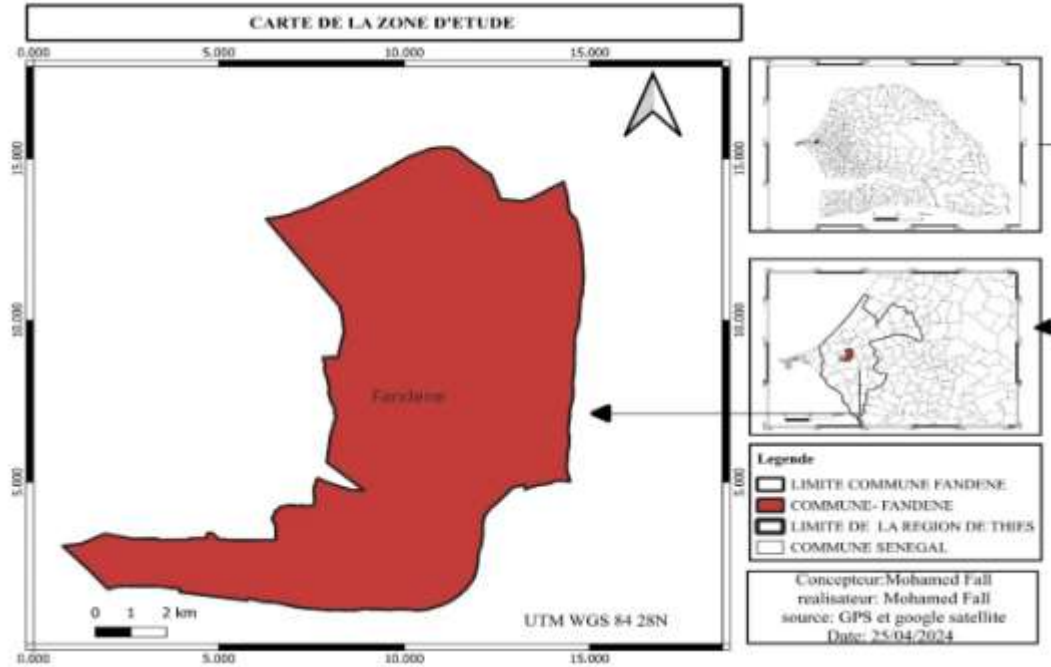


Figure 1: Map of the study area

#### List of photos:-

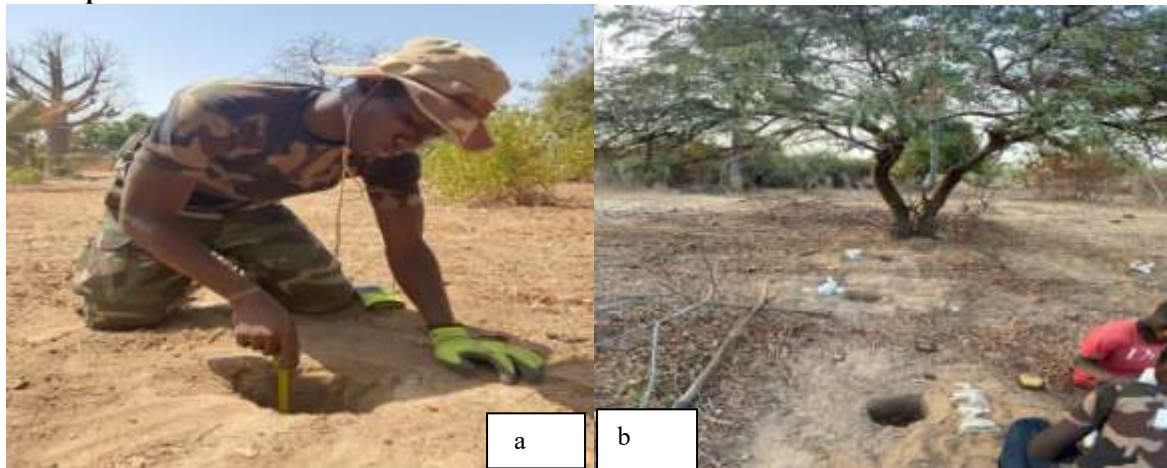


Photo 1: measuring profile depth (a) and arranging profiles according to the different radii of the crown (b)

#### Discussion:-

##### Physical characteristics of soils under the influence of *C. sieberiana*:-

The significant difference observed between C2 and C3 for sand may be related to the gradual development of *C. sieberiana* root system and its ability to trap and retain soil particles over time. The absence of significant differences in canopy radius suggests that the influence of *C. sieberiana* on soil texture is relatively uniform around the tree, corroborating the findings of <sup>12</sup>.

##### Chemical characteristics of soils under the influence of *C. sieberiana*:-

##### Effect of diameter classes:-

Although moderate, the soil acidity caused by *C. sieberiana* is more pronounced in C3 trees. This difference could be related to the accumulation of OM and the degradation of leaves and roots, which release organic acids into the

soil. Diameter classes significantly influenced pH, OC, OM, N and the C/N ratio. These results corroborate those of<sup>33</sup>, which show that trees of different diameters can have different root systems and litter inputs, thereby altering the soil chemical composition under the canopy. Larger trees can store and recycle more nutrients. C2 class trees exhibited the highest OC and OM contents, likely due to their growth stage and maximum biomass accumulation<sup>34</sup>. In contrast, trees in class C3 had lower values, possibly due to less advanced development or faster litter decomposition, given the lowest observed soil pH. These results confirm the previous research findings of<sup>12</sup>.

#### **Effects of canopy radius:-**

In soil nutrient cycling, plants alter the spatial distribution of nutrients, OM, and other ecosystem properties through their physical presence and associated influences<sup>17</sup>. Indeed, OC and OM were higher at 1/3R and 2/3R. However, the results showed that N increased as one moved farther from the trunk. Our results corroborate those obtained by<sup>36</sup> under *Balanites egyptiaca* and under *Vitellaria paradoxa*<sup>37</sup> for OC and OM, but not for N. The elevated N content outside the canopy may be due to conditions that promote N-fixing bacteria or other soil microorganisms that increase N levels.

#### **Effects of depth:-**

A highly significant effect of depth was observed across all variables studied, except pH. Organic carbon and OM levels decreased with depth, driven by reduced OM inputs and lower microbial activity in deeper layers<sup>38</sup>. The same trend was reported by<sup>39</sup> under *Piliostigma reticulatum*. pH is less affected because it tends to be more stable and is influenced by factors such as parent material and drainage conditions<sup>40, 17</sup>. Overall, the results indicated that the study site was of low fertility. Improving OC content under the canopy allows surpassing the theoretical critical threshold of 1.5% OM, but not the minimum threshold of 2.5%. The decrease in pH under the C3 is minor, but it falls below the aluminium acidity constant (= 5.5), which could be detrimental to crops due to aluminium toxicity.

#### **Conclusion:-**

The study of the influence of *C. sieberiana* DC on the physicochemical properties of soils in Fandene highlighted several key points regarding soil fertility under this tree species. The main objectives of this research were to assess the variability of fertiliser content under and outside the canopy of *C. sieberiana*, to determine these levels by crown radius and diameter classes, and to examine variations with sampling depth.

The results showed higher levels of OC and OM beneath the canopy than outside it. They are also higher at C2, two-thirds of the way up the canopy, at a depth of 0-20cm. However, N levels increase as one moves away from the trunk. The physicochemical parameter levels vary with depth. The highest levels were observed at 0-20cm, except for pH. These high surface levels confirm the vertical gradients typical of forest soils. This study highlights the ecological importance of *C. sieberiana* in soil fertility management in arid and semi-arid regions.

#### **In light of the results, the following recommendations are proposed:**

- Promote the sustainable management of *C. sieberiana* to enhance marginal land, act as a barrier against desertification, and for erosion control ;
- Continue investigating other chemical properties ;
- Raise awareness among farmers and local communities of the ecological and agronomic benefits of *C. sieberiana*.

#### **Acknowledgements:-**

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#### **References:-**

1. Macedo T., Federico F., David M.P., Andreia P.O., Nelson G.M.G, Ángel G.I., Patrícia V., Luísa A., Paula B.A. *Cassia sieberiana* DC. leaves modulate LPS-induced inflammatory response in THP-1 cells and inhibit eicosanoid-metabolizing enzymes Journal of Ethnopharmacology, Volume 269, 6 April 2021, 113746 <https://doi.org/10.1016/j.jep.2020.113746>
2. Maydel H.J.V., 1983. Arbres et arbustes du Sahel-leurs caractéristiques et leurs utilisations, 203 p
3. Bagniaka A., moliva J., 2009. Formulation et essais de pommades cicatrisantes à base d'extraits de racines de *Cassia sieberiana* DC (caesalpiniaceae), Retrieved on <http://bibnum.ucad.sn/viewer.php?c=thm&amp;d=thm%5f46765>

4. Olapade A. A., Ajayi O. A., Ajayi I. A., 2013. Physical and chemical properties of Cassia sieberiana seeds, 2p, Retrieved on [https://www.researchgate.net/publication/287534958\\_Physical\\_and\\_chemical\\_properties\\_of\\_Cassia\\_sieberiana\\_seeds](https://www.researchgate.net/publication/287534958_Physical_and_chemical_properties_of_Cassia_sieberiana_seeds)
5. Mette A., Paulin O., Boussim I., Guinko S., 2006. La flore medicinale de la Forêt Classée de Niangoloko (Burkina Faso). Etudes flor. veg. Burkina Faso 10, 5-16. Retrieved on [https://d1wqtxs1x7le7.cloudfront.net/45091666/La\\_flore\\_medicinale\\_de\\_la\\_Fort\\_Classée\\_d20160426-30025-1mleef6-libre.pdf?1461657575=&response-content\\_disposition=inline%3B+filename%3DLa\\_flore\\_medicinale\\_de\\_la\\_Fort\\_Classée.pdf&Expires](https://d1wqtxs1x7le7.cloudfront.net/45091666/La_flore_medicinale_de_la_Fort_Classée_d20160426-30025-1mleef6-libre.pdf?1461657575=&response-content_disposition=inline%3B+filename%3DLa_flore_medicinale_de_la_Fort_Classée.pdf&Expires)
6. Kerharo J & Adam J. G., 1964. Plantes medicinales et toxiques des Peuls et des Toucouleurs du Senegal. Journal d'agriculture traditionnelle et de botanique appliquée, 11(10), 384-444. <https://doi.org/10.3406/jatba.1964.2785>
7. Aliyu Z., Yusha'u M., & Aliyu, B. S., 2013. Anti-Malarial Activity of Cassia Sieberiana Leaf Extracts. The Open Conference Proceedings Journal 2013, 4 : 72-76. <http://dx.doi.org/10.2174/2210289201304010072>
8. Archer M A., Agyei T A., Mintah S. O., Atta P., Junior A., Kumadoh D., & Asiedu-Larbi J., 2019. Medicinal Uses of Cassia Sieberiana; A Review. International Journal of Sciences, 48(2). <https://core.ac.uk/download/pdf/249336727.pdf>
9. Schmelzer G.H., 2008. Ressources vegetales de l'Afrique tropicale. 11,1 : Plantes medicinales, 167-168p.
10. Alexandre D.Y., 2002. Initiation à l'agroforesterie en zone sahelienne : Les arbres des champs du Plateau Central au Burkina Faso, [en ligne], p 179. Retrieved on [https://horizon.documentation.ird.fr/exl-doc/pleins\\_textes/divers12-10/010028958.pdf](https://horizon.documentation.ird.fr/exl-doc/pleins_textes/divers12-10/010028958.pdf)
11. Legoux A., 2022. Evaluation multicritere de la durabilite des exploitations agricoles integrant l'agroforesterie, 12-13p.
12. Gliński J., Horabik J., Lipiec J., 2011. Encyclopedia of Agrophysics. <https://doi.org/10.1007/978-90-481-3585-1>
13. Ohta S (1990) Initial soil changes associated with afforestation with Acacia auriculiformis and Pinus kesiya on denuded grasslands of the Pantabangan area, Central Luzon, the Philippines. Soil Science Plant Nutrition 36(4):633–643
14. MOUAS-BOURBIA, S.; BARRE, P.; LAMARA MAHAMED, S.; KERKOU, F.; ISSAOUN, D.; BOUAHMED, A.; BOUDIAF-NAIT KACI, M.; DERRIDJ, A.; VELDE, B. 2020. Rhizospheric effect on soil chemical properties: case of Olea europaea L. groves at two contrasting vegetative periods. Agrochimica: International Journal of Plant Chemistry, Soil Science & Plant Nutrition of the University of Pisa, 2020, Vol 64, Issue 3, p297 ISSN 0002-1857, Academic Journal DOI, 10.12871/00021857202037
15. Dalila M. F., 2016. Impacts des systemes agroforestiers sur les proprietes physico-chimiques, hydriques et la fertilite des sols en milieux semi-arides Cas de la plaine des Bordjias, 11p.
16. Boffa J.-M., 2000. Les parcs agroforestiers en Afrique subsaharienne, 82p. Retrieved on <https://books.google.fr/books?hl=fr&lr=&id=f4T5ldC3pfgC&oi=fnd&pg=PR3&dq=Boffa+J.-M.,+2000.+Les+parcs+agroforestiers+en+Afrique+subsaharienne,+82p.&ots=z-FgvQR1C9&sig=bcmnm-t0GMraqDcgrn3qQTa9D08#v=onepage&q&f=false>
17. Barth R. C., Klemmedson J.O., 1978. Shrub-induced Spatial Patterns of Dry Matter, Nitrogen, and Organic Carbon, 804-809p, <https://doi.org/10.2136/sssaj1978.03615995004200050031x>
18. Giller K.E., Cadisch G., (1995). Future benefits from biological nitrogen fixation: An ecological approach to agriculture. Plant Soil 174, 255–277 (1995). <https://doi.org/10.1007/BF00032251>
19. Tanoh G A., Ettien J B D., & Bouadou F B O., 2022. Effets de la biomasse de deux legumineuses sur la fertilite des sols et le rendement de l'igname dans le Sud-ouest de la Côte d'Ivoire.
20. Hinsinger P., Plassard C., Tang C., Jaillard B., 2003. Origins of root-mediated pH changes in the rhizosphere and their responses to environmental constraints: A review. Plant and Soil 248, 43–59 (2003). <https://doi.org/10.1023/A:1022371130939>
21. Drechsel P, Glaser B, Zech W (1991) Effect of 4 multipurpose tree species on soil amelioration during tree fallow in Central Togo. Agroforestry Systems 16(3):193–202
22. Bernhard-Reversat F (1996) Nitrogen cycling in tree plantations grown on a poor sandy savanna soil in Congo. Applied Soil Ecology 4(2):161–172
23. Deans JD, Diagne O, Lindley DK, Dione M, Parkinson JA (1999) Nutrient and organic-matter accumulation in Acacia senegal fallows over 18 years. Forest Ecology Management 124(2):153–167
24. Szott LT, Palm CA, Buresh RJ (1999) Ecosystem fertility and fallow function in the humid and subhumid tropics. Agroforestry Systems 47(1–3):163–196

25. Mugunga C. P., Mugumo D. T., 2013. *Acacia sieberiana* Effects on Soil Properties and Plant Diversity in Songa Pastures, Rwanda, 1-11p, <https://doi.org/10.1155/2013/237525>
26. Bayala J, Sanou J, Teklehaimanot Z, Ouedraogo SJ, Kalinganire A, Coe R, van Noordwijk M (2015) Advances in knowledge of processes in soil–tree–crop interactions in parkland systems in the West African Sahel: A review. *Agriculture, Ecosystems and Environment* 205:25–35
27. Sileshi GW (2016). The magnitude and spatial extent of influence of *Faidherbia albida* trees on soil properties and primary productivity in drylands. *Journal of Arid Environments* 132:1-14
28. Dubiez E, Freycon V, Marien JN, Peltier R, Harmand JM (2019) Long term impact of *Acacia auriculiformis* woodlots growing in rotation with cassava and maize on the carbon and nutrient contents of savannah sandy soils in the humid tropics (Democratic Republic of Congo). *Agroforestry Systems* 93:1167–1178
30. Rounsard O et al. (2020) How far does the tree affect the crop in agroforestry? New spatial analysis methods in a *Faidherbia* parkland. *Agriculture, Ecosystems and Environment* 296: 106928
31. Kidanu s., Mamo T.S., 2005. Biomass production of *Eucalyptus* boundary plantations and their effect on crop productivity on Ethiopian highland Vertisols. *Agroforestry*, 281-290p, <https://doi.org/10.1007/s10457-005-5169-z>
32. Sall A., Toure A., Kane A., Niang F.A., 2019. Contribution à l'étude de la vulnérabilité des terres de cultures de la région de Thiès (Sénégal) à l'aide de la télédétection et des systèmes d'information géographique (SIG). *Journal of Animal & Plant Sciences*, 67316746. <https://doi.org/10.35759/JANmPLSci.v41-1.1>
33. Grant C.D., 2003. *The Nature and Properties of Soils*, 13th Edition, 393-394p [https://doi.org/10.1016/S0167-8809\(02\)00230-X](https://doi.org/10.1016/S0167-8809(02)00230-X)
34. Harmand JM, Njiti CF (1998) Effets de jachères agroforestières sur les propriétés d'un sol ferrugineux et sur la production céréalière. *Agriculture et Développement* 18:21–30
35. Jenny H. 1994. *Factors of soil formation : A system of quantitative pedology*, 281p. Retrieved on <https://books.google.fr/books?hl=fr&lr=&id=orjZZS3H-hAC&oi=fnd&pg=PP1&dq=Jenny+H.+1994.+Factors+of+soil+formation%E2%80%AF:+A+system+of+quantitative+pedology,+281p&ots=fLjO84gUhk&sig=FuNdFfALLdysRcSVUIQVZsopi-w#v=onepage&q&f=false>
36. Boubacar I., Idrissa S., Yacouba B., Ambouta J.M., 2019. Effet de *Balanites aegyptiacus* sur le niveau de fertilité chimique d'un sol de terrasse du fleuve Niger, p 2-3, <https://doi.org/10.4314/jab.v137i1.2>
37. Bayala J., Mando A., Teklehaimanot Z., Ouedraogo S. J., 2005. Nutrient release from decomposing leaf mulches of *karite* (*Vitellaria paradoxa*) and *nere* (*Parkia biglobosa*) under semi-arid conditions in Burkina Faso, West Africa. *Soil Biology and Biochemistry*, 37(3), 533-539p. <https://doi.org/10.1016/j.soilbio.2004.08.015>
38. Lal R., 2004. Soil Carbon Sequestration Impacts on Global Climate Change and Food Security. *Science*, 304(5677), 1623-1627p, <https://doi.org/10.1126/science.1097396>
39. Gnissien Moussa, Kalifa Coulibaly, Moussa Barro, Jean-Marie Douzet, Laurent Cournac, et al.. Effets longueduree de differentes densites de *Piliostigma reticulatum* (DC) Hochst sur le stockage et la dynamique du carbone et de l'eau dans un Plinthosol epipetrique en zone nord-soudanienne du Burkina Faso. *International Journal of Biological and Chemical Sciences*, 2023, 17 (3), pp.1220-1236. [10.4314/ijbcs.v17i3.36](https://doi.org/10.4314/ijbcs.v17i3.36). hal-05182393
40. Chapin F. S., Matson P. A., Mooney H.A., 2002. *Terrestrial Production Processes*. In: *Principles of Terrestrial Ecosystem Ecology*. Springer, New York, NY. pp 123–150, [https://doi.org/10.1007/0-387-21663-4\\_6](https://doi.org/10.1007/0-387-21663-4_6)