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Endogenous Knowledge and Physico-Chemical Characterisation of the Agropedological Potential of Soils with a Plinthic Aspect in the Seguela Department (North-West of Cote d'Ivoire)

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Abstract

As part of the inventory of endogenous soil knowledge in Cote d'Ivoire, research was carried out on plinthitic soils (cuirassed soils) in Seguela, in the north-west of the country. The study combined surveys of farmers, laboratory analysis of the physico-chemical characteristics of the soils and statistical analysis of the data obtained. The results show that the vast majority of farmers own leathery land, but only some manage to cultivate it, often out of necessity due to dwindling arable land, while others give it up because of the difficulty of the work. Farmers recognise these armoured areas by the presence of hills and typical plant species. These plant species play an important role in the decision to cultivate these soils. Plants such as Isoberlinia doka (Caesalpiniaceae), Uapaca togoensis (Euphorbiaceae), Combretum micrantum and Manotes kerstingii (Dipterocarpaceae) are indicative of the fertility of cuirasse soils. On the other hand, the presence of Pericopsis laxiflora (fabaceae), Combretum molle (Combretaceae), Gardenia ternifolia (Rubiaceae) and Combretum lecardi on hardpan soils indicates the poverty of these soils. Compared with non cuirassed soils, cuirassed soils can be less acidic, with a higher capcity of exchangeable bases. These results attest to some local knowledge in terms of plant species indicative of soil fertility. However, the presence of slabs of armour would constitute obstacles to their agricultural development.

Keywords: Endogenous knowledge; physico-chemical characteristics; plinthitic soil; Seguela; North-West Cote d'Ivoire

Introduction

Armour-clay soils, also known as ferruginous or ferricretic soils, are characteristic soil formations of tropical and subtropical zones. They form under the influence of complex pedogenetic processes involving the accumulation of iron, aluminium and sometimes silica, giving rise to a hard, impermeable crust on the surface or at depth (Yoboue et al., 2022). These soils are widespread in Africa, Latin America and Asia, where they cover vast areas. Against a backdrop of rapid population growth and increasing pressure on agricultural land, these marginalised soils are attracting increasing attention for their agronomic potential and their contribution to food security.

The interest in assessing the physico-chemical properties of armour-clad soils lies in their ability to support certain agricultural practices through appropriate management techniques. However, their intrinsic low fertility, combined with physical constraints (impermeability, shallow exploitable depth), often limits their agricultural use. In this context, an in-depth study of the physico-chemical characteristics of these soils is essential to gain a better understanding of their agronomic potential and propose sustainable management strategies (Toure, 2023; Koffi, 2023).

Despite their abundance in many tropical regions, leathery soils remain under-exploited because of their low fertility, compacted structure and low water retention capacity. As a result, these constraints limit their agricultural use, raising crucial questions. Nevertheless, these soils can be rehabilitated to a large extent for sustainable agricultural production, provided that the physico-chemical parameters that directly influence their fertility and suitability for cultivation are taken into account (Kouakou et al., 2019).

Furthermore, variations in the mineralogical and chemical composition of these soils, depending on the region and climatic conditions, require specific studies to better understand their dynamics and potential (Diallo et al., 2015).

The issue is therefore to identify the critical parameters that determine the agronomic capacity of armour-clad soils, and the techniques that can be implemented to improve their agricultural productivity.

In order to find methods for agricultural development of armour-clad soils, it became necessary to carry out a study on: “Physico-chemical characterisation and diagnosis of the agropedological potential of soils with a plinthitic aspect in the department of Seguela in west-central Cote d’Ivoire”.

The aim of this study is to provide a scientific basis for the sustainable management of armour-clad soils, taking account of their specific characteristics. The specific objectives of this scientific approach are as follows:

- Characterising knowledge about bioindicators for managing the fertility of leathery soils.
- Assessing the physical and chemical quality of these soils for agronomic performance.

Materials and Methods

Study site

The work was carried out in the Worodougou region located in the centre-west of Cote d’Ivoire, comprising two departments (Seguela and Kani departments). The department of Seguela is located between parallels 8° and 8°20’N and meridians 6°26’ and 6°46’W (Figure 1).

The climate is transitional tropical (Jourda, 2009), with two contrasting seasons: the rainy season (monthly rainfall in excess of 50 mm) extends from April May to October and the dry season from November to May the following year.

The Seguela granite massif consists of granodiorites with a grainy texture and mineralogy composed of 60% quartz, plagioclase and microcline. Ferromagnesian minerals include hornblende, biotite and a few opaque oxides (Gnoleba et al., 2020).

Work by Pouclet et al., (2004) in the Seguela department has shown that this region is known for its diamond field fed by Kimberlite and Lamproïte dykes. These undeformed and unmetamorphosed dykes cut through Birimian formations trending N170°.

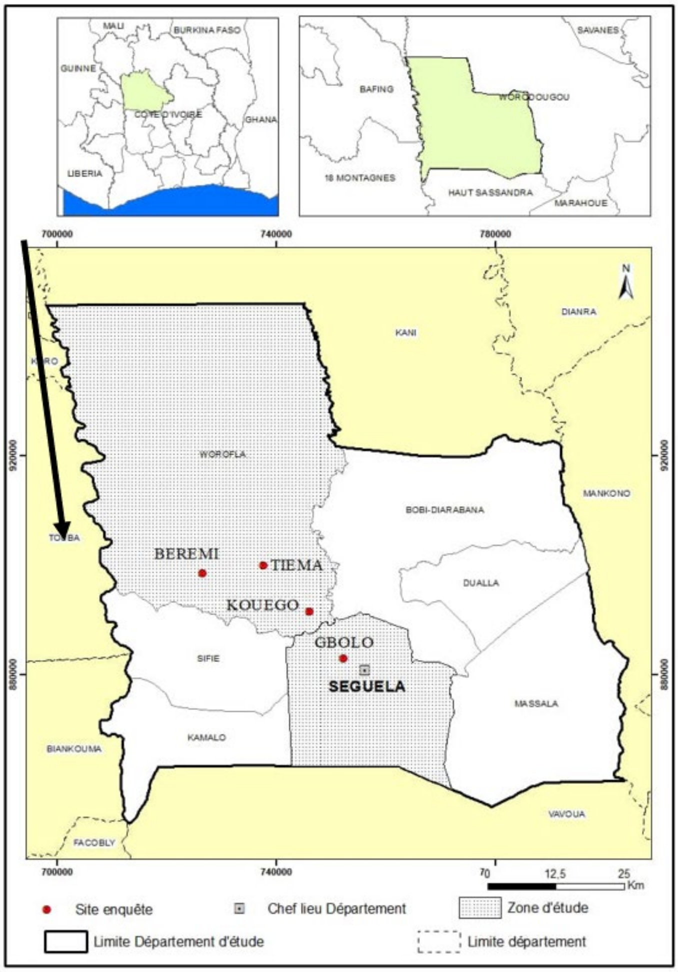

Figure 1: Map of the study area.

Method for characterising local technical knowledge

The survey method used highlights the common fund of knowledge and its coherence with so-called traditional practices. At the same time, at the individual level, it enables us to analyse the role of the individual variant of knowledge in the implementation of practices. This method comprises three stages.

The first is an exploratory survey of farmers through individual and collective discussions, to understand the common fund of knowledge on bioindicators of the fertility and poverty of these armour-clad soils, as well as the crops that can grow best on these soils.

The second concerns a sample of farmers subjected to an individual survey. A survey form is constructed from the pre-identified entities and variables. The farmers explain the variables they use to describe each of the entities. This stage is used to construct grids for characterising each farmer's local technical knowledge (individual variant of knowledge).

During the third phase, the summary grid characterising local technical knowledge is presented to the village assembly. The farmers correct any errors and complete any missing data. The search for a consensus around the shared knowledge serves to validate the technique (common fund of knowledge).

A questionnaire was sent to 148 people in four representative villages in the department of Seguela. These were Gbolo, Kouego, Tiema and Bereni. In addition, plant species characteristic of cuirasses soils were sampled and identified by their scientific names at the Centre National Floristique (CNF) at the Universite Felix Houphouët-Boigny in Cocody.

Soil sampling and laboratory analysis

The choice of observation points was based on the law of horizontal and vertical zonality [9], in accordance with the occurrence of blocks and slabs of armour in outcrop.

In order to carry out a comparative analysis, soil samples were taken from the following areas at a depth of 0-20 cm, using the following three methods:

- On armoured soil and under the canopy of the soil fertility indicator plant species (SC- PIF);
- On armoured soil and under the canopy of the soil poverty indicator plant species (SC-PIP);
- On non-hardpan soil outside the canopy of the fertility and poverty indicator plant species soil (SNC-T0), as a control treatment;

The samples were taken to the laboratory for chemical analysis. The following parameters were analysed: carbon, total nitrogen, organic matter, cation exchange capacity, exchangeable bases and assimilable phosphorus. They were carried out using standard methods, as reported by Gole et al. (2022). The pHwater measurement was carried out using an electronic pH meter, in a soil suspension in water in a ratio of 1/2.5. The organic carbon (C) content was determined according to the Walkley and Black method. The organic matter (OM) rate results from that of carbon through the formula OM = C x 1.724. As for total nitrogen, it was determined by the Kjeldahl method. The exchangeable bases were extracted through a solution of ammonium acetate buffered at pH 7, followed by saturation with NaCl for the determination of cation exchange capacity (CEC). The available phosphorus was determined by the Olsen method.

Statistical analysis of data

XLSTAT Version 2016 software was used to carry out the statistical analyses. The analyses included analysis of variance (ANOVA) to compare soils of different characteristics and Principal Component Analysis (PCA) to establish a correlation between soil chemical parameters and soil bioindicators, together with a Pearson correlation matrix.

The bioindicator frequency diagram was drawn up using the 2018 version of Microsoft Office Excel.

Results

Local technical knowledge used to manage the fertility of armoured soils

With regard to the presence of armour on the land, 109 farmers out of 148 had armour and rock debris on their land. Of these, only 46 farmers, a rate of 42%, were able to grow crops on the armour-plated part of their land, while the remaining 63 were unable to make use of the armour-plated part of their land, citing the arduous nature of working on armour-plated soils. These difficulties relate to the development of these soils, in particular clearing and ploughing, due to the presence of numerous boulders on the surface. Users of these soils for agricultural purposes get round this difficulty by using herbicides. Apart from this practice, many farmers lack suitable techniques for developing the soil.

Farmers who turn to these plinthitic soils mention their good fertility for farming, attesting that crops grow well without fertiliser.

Different geological formations in the study area

The Seguela study area is dominated by metamorphic formations. The geological bedrock of the soils was found to have formed on metagabbro and especially green schist. These different geological formations are illustrated in figure 2.

a. Metagabro **b. Green schiste**

Figure 2: Geological formations in the study area.

Process of forming breastplates

Two processes have been observed in the formation of cuirasses in the department of Seguela. Firstly, the parent rock undergoes a transformation to form the cuirasses. Secondly, the heavy load of coarse elements is taken up en masse by the clay to form cuirasses.

Different types of armour found at Seguela

These cuirasses are found in blocks or slabs, in outcrops or at varying depths, on hilltops or flanks (Figure 3).

a: Massive facies **b: Pisolithic facies** **c: Conglomerate facies**

Figure 3: Different types of armour found at Séguéla.

Floristic inventory of armoured areas according to local knowledge

According to the people of Seguela, the choice of soil to cultivate depends on soil fertility indicator plants.

Some of the plant species or types of plant most commonly found in this area are mentioned in table 1.

Scientific names	***Names in Koyaka***	***Soil bioindicator***
Loudetia arundinacea (Hochst.ex. A.Rich) Steud.(poaceae)	Sassa bihin	Poor soil
*Chromonola odorat*a	Indépendant	Fertile soil
Parinari curatellifolia (chrysobalanceae)	Toutou	Fertile soil
Terminalia macroptera (Combretaceae)	Bakoho	Fertile soil
Maerua anyolensis (capparaceae)	Brêbrê	Poor soil
Terminalia schimperiana (combretaceae)	Kohougo	Fertile soil
Crossopteryx febrifuga (Rubiaceae)	Tientien ou tchintchin	Fertile soil
Trema orientalis (cannàbaceae)	Soufola	Poor soil
Margaritaria discoidea (Euphorbiaceae)	Baguôhô	Fertile soil
Gardenia erubescens (Rubiaceae)	Lolongo	Poor soil
Piliostigma thonningû (Fabaceae)	Gnamango	Fertile soil
Pericopsis laxiflora (fabaceae)	Kouhokouho	Poor soil
Dichrostachys cinerea (Fabaceae)	Krogboho	Poor soil
Daniella oliveri (Fabaceae)	Tchinko	Poor soil

Table 1: Inventory of plant species characterizing armoured soils.

Farmers recognise cuirassed areas by the presence of hills and plant species typical of cuirassed areas. Thus, according to these farmers, plants such as *Chromonola odorata*, *Parinari curatellifolia* (Chrysobalanceae), *Terminalia macroptera* (Combretaceae), *Terminalia schimperiana* (Combretaceae), *Crossopteryx febrifuga* (Rubiaceae) and *Piliostigma thonningu* (Fabaceae) are indicator plants for the fertility of cuirassed soils (Figure 4).

Figure 4: Plants indicating fertility of harpan soil.

However, certain plants such as *Maerua anyolensis* (Capparaceae), *Trema orientalis* (Cannabaceae), *Gardenia erubescens* (Rubiaceae), *Dichrostachys cinerea* (Fabaceae), *Daniella oliveri* (Fabaceae) are plants that indicate poverty or soil unsuitable for agriculture (Figure 5).

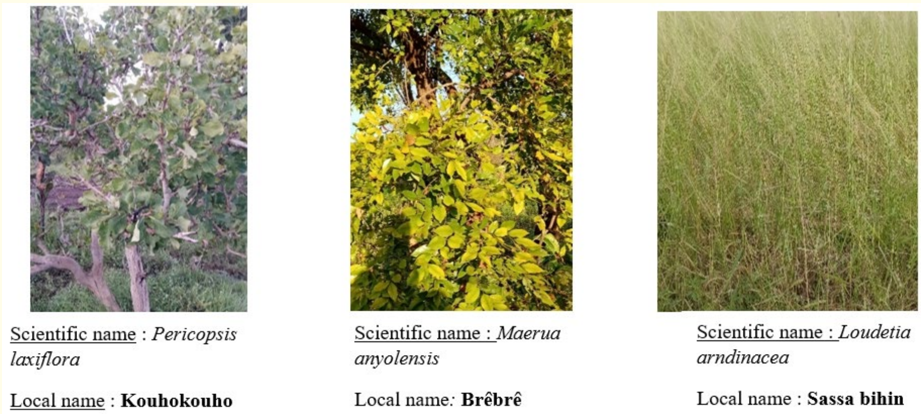

Figure 5: Plants indicating hardpan soil poverty.

Some of them have been observed with 80% of observation frequency. It's hte cases of Sassa bihin (*Loudetia arundinacea*), Bakoho (*Terminalia macroptera*), Brebre (*Maerua anyolensis*), Baguoho (*Margaritaria discoidea*) et Lolongo (*Gardenia erubescens*) (Figure 6).

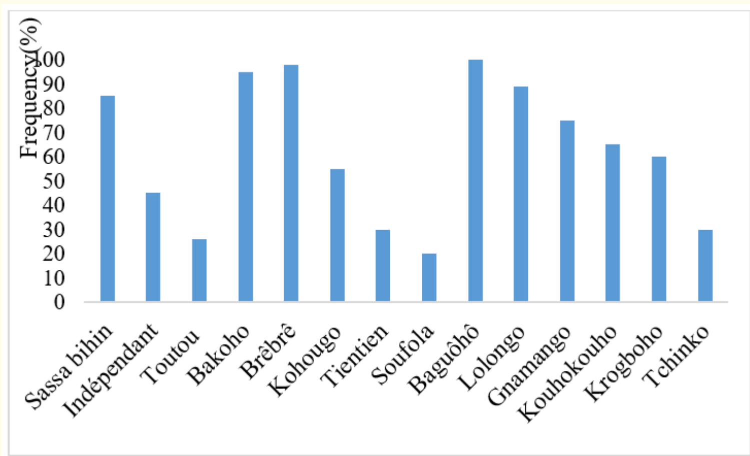

Figure 6: Frequency of plants according to the survey in the department of Séguéla.

Comparative analysis of soil characteristics

The results recorded in Table 2 provide a comparison between the characteristics of soils in a hardened state or not, along with indicators of soil fertility status.

These results generally show that the soil characteristics under the canopy of plants indicative of fertility are relatively better compared to those of the soil under the canopy of species indicative of soil poverty. These soils with plants indicative of fertility even showed that for certain parameters such as pH and cation exchange capacity (CEC), the values are relatively higher than those observed in the control soil without crust. This effectively demonstrates the capabilities of the following plants, according to indigenous knowledge:

- *Terminalia macroptera*, *Piliostigma thonningu* and *Parinari curatellifolia* to show soil fertility; but this has not been verified for plant species such as *Chromonola odorata*;
- *Maerua anyolensis*, *Pericopsis laxiflora* and *Loudetia arndinacea*, to indicate soil poverty; however, this has not been established for *Dichrostachys cinerea*.

Treatment	***pH water***	***C***	***N***	***MO***	***C/N***	***P***	***CEC***	***Ca^{2+}***	***Mg^{2+}***	***K^{+}***	***Na^{+}***
		($g.kg^{-1}$)				***($mg.kg^{-1}$)***	***($cmol.kg^{-1}$)***				
SC-PIF	6,56aa	27,2aa	2,0aa	4,68aa	13,54aa	52,97aa	31,60aa	3,14aa	1,98aa	0,033aa	0,05aa
SC-PIP	5,93bb	12,6aa	1,4aa	2,16aa	9,16ab	40,00bb	12,57aa	0,87aa	0,40aa	0,084aa	0,16aa
SNC-T0	6,10ab	29,5aa	2,2aa	5,07aa	12,97aa	54,07aa	28,67aa	3,27aa	1,88aa	0,122aa	0,05aa
Pr > F	0,044*	0,183	0,251	0,183	0,067	0,001**	0,199	0,328	0,138	0,378	0,400
Significant	Yes	No	No	No	No	Yes	No	No	No	No	No

Table 2: Values of the chemical parameters of the soil in Séguéla.

Means assigned the same letter in the same column are not significantly different at the $\alpha_{=}0,05$ threshold according to the SDCF test *: significant; **: highly significant;

SC-PIF: hardpan soil, under fertility indicator plant.

SC-PIP: hardpan soil, under poverty indicator plant.

SNC-T0: non-hardpan soil outside the canopy of the fertility and poverty indicator plant species soil, as a control treatment.

Correlation matrix

Correlation matrice between the characteristics of the hardpan soil under the canopy of plant species indicative of fertility

Table 3 shows the Pearson correlation coefficients between different soil chemical parameters (pH, C, N, P, C/N, CEC, Ca^{2+}, Mg^{2+}, K^{+}, Na^{+}, OM) measured under the canopy of plants indicating the state of fertility at Seguela.

The pH is negatively correlated with C and OM with r =-0.889. This may indicate that acid soils are less rich in C and OM.

There was a negative correlation between C/N and Na^{+} (r =-0.832). This means that a high C/N ratio, which indicates a low mineralisation rate of organic matter, can limit the availability of Na^{+}. Finally, a strong correlation between Ca^{2+} and Mg^{2+} (r = 0.917), which means that soils rich in Ca^{2+} are also rich in Mg^{2+}.

Correlation matrices between the characteristics of the hardpan soil under the canopy of plant species indicative of soil poverty

The Pearson correlation matrix in Table 4 shows a negative correlation between pHwater and Mg^{2+}, K^{+}, with respective coefficients -0.911 and -0.888). This implies that more acidic soils have higher concentrations of Mg^{2+} and K^{+}. A strong correlation is observed between C and CEC, with r = 0.842. There is also a negative correlation between N and P, CEC, and Ca^{2+} with respectively r = -0.844; r = -0.843 and r = -0.791.

Variables	*pH water*	*C*	*N*	*C/N*	*P*	*CEC*	*Ca^{2+}*	*Mg2+*	*K^+*	*Na^+*	*MO*
pH water	1										
C	-0,889	1									
N	0,465	-0,472	1								
C/N	-0,112	0,086	-0,432	1							
P	-0,028	0,389	-0,570	0,470	1						
CEC	-0,413	0,621	-0,579	-0,343	0,482	1					
Ca2+	0,484	-0,068	0,163	-0,428	0,487	0,450	1				
Mg2+	0,454	-0,086	-0,086	-0,377	0,507	0,512	0,917	1			
K+	-0,659	0,726	0,198	-0,467	-0,150	0,384	0,058	-0,092	1		
Na+	0,437	-0,549	0,612	-0,832	-0,730	-0,158	0,197	0,215	0,071	1	
MO	-0,889	1,000	-0,472	0,086	0,389	0,621	-0,068	-0,086	0,726	-0,549	1

Values in bold are different from 0 at a significance level of alpha=0.05.

Table 3: Correlation matrices between the characteristic parameters of the cuirassed soil excluding canopy of plants indicating the state of fertility at Séguéla.

However, positive correlations were observed between N and Na^+ (r = 0.983), the C/N ratio and P, CEC and Ca^{2+} (r = 0.778; r = 0.836; r = 0.842, respectively). Also a positive correlation was found between P and CEC, suggesting that P-rich soils also have high CEC. CEC is negatively correlated with Na^+ (r = -0.838) while CEC is positively correlated with OM (r = 0.842). Finally, a negative correlation between Ca^{2+} and Na^+ (r = -0.783) and a positive correlation between Mg^{2+} and K^+ with r = 0.814.

Variables	*pH water*	*C*	*N*	*C/N*	*P*	*CEC*	*Ca^{2+}*	*Mg^{2+}*	*K^+*	*Na^+*	*MO*
pH water	1										
C	-0,158	1									
N	0,265	-0,686	1								
C/N	-0,257	0,584	-0,966	1							
P	-0,430	0,749	-0,844	0,778	1						
CEC	-0,387	0,842	-0,843	0,836	0,900	1					
Ca^{2+}	0,225	0,508	-0,791	0,842	0,641	0,711	1				
Mg^{2+}	-0,911	0,319	-0,482	0,540	0,577	0,647	0,127	1			
K^+	-0,888	-0,047	-0,359	0,372	0,483	0,313	-0,044	0,814	1		
Na^+	0,248	-0,695	0,983	-0,975	-0,778	-0,838	-0,783	-0,496	-0,302	1	
MO	-0,158	1,000	-0,686	0,584	0,749	0,842	0,508	0,319	-0,047	-0,695	1

Values in bold are different from 0 at significance level alpha = 0.05.

Table 4: Correlation matrice between characteristic parameters of hardpan soil under the canopy of plant indicative of soil poverty.

Correlation matrice between the characteristics of soil outside of the canopy of plant species indicative of soil fertility status

The table 5 contains the correlation coefficients between soil parameters outside the canopy of plant species indicative of soil fertility status. In this table, the most important result is the negative correlations between pHwater and P and the positive one between C and CEC, Ca^{2+}, Mg^{2+} and Organic Matter (OM).

Principal Component Analysis: chemical parameters of soil fertility indicator plants sampled at Seguela

Figure 6 shows whether there is a correlation between the fertility indicators and the physico-chemical parameters of the soil samples studied.

It shows that two axes (F1 and F2) account for 69.07% of total inertia. The F1 axis alone contributed 51.34%, compared with 17.72% for the F2 axis. Variables such as C, N, OM, P, CEC, Na and Mg of hardpan soils under plants such as Soufola, Lolongo, Kouhokouho, Tchintchin, Krogboho, Kouho, Brebre, Toutou and these same parameter in control soils (non-hardpan soils) are correlated with F1. However, variables such as C/N, Ca^{2+} in hardpan soils under plant like Independent, Sassa bihin, Gnamango and some control soils are very close to the F2 axis. This result confirms the indigenous knownledge for some plants as an indicative of fertility or poverty of soil. But this is not establish for some plants.

Variables	*pH water*	*C*	*N*	*C/N*	*P*	*CEC*	*Ca^{2+}*	*Mg^{2+}*	*K^+*	*Na^+*	*MO*
pH water	1										
C	-0,295	1									
N	0,361	-0,481	1								
C/N	-0,170	0,250	-0,463	1							
P	-0,691	0,487	-0,444	0,539	1						
CEC	0,275	0,724	-0,472	0,249	0,130	1					
Ca^{2+}	0,222	0,611	-0,310	0,216	0,307	0,699	1				
Mg^{2+}	0,306	0,599	-0,285	0,324	0,303	0,748	0,952	1			
K^+	-0,463	-0,034	0,282	0,113	0,425	-0,398	-0,412	-0,376	1		
Na^+	0,371	-0,478	0,999	-0,435	-0,435	-0,470	-0,302	-0,270	0,278	1	
MO	-0,295	1,000	-0,481	0,250	0,487	0,724	0,611	0,599	-0,034	-0,478	1

Table 5: Correlation matrice between the characteristics of soil outside the canopy of plant species indicative of soil fertility status.

Discussion

Chemical analysis of Seguela soil

Soils are generally acidic or slightly acidic in the different areas studied. The acidity of these soils could be attributed to very low levels of base saturation. This trend in the relationship between pH and saturation level was noted by Julien et al. (2023).

However, many authors have reported that the slightly acidic soils is not a constraint for some plant such as cocoa because, these plants can develop on soils with an acid pH (pH 4.5- 6) or slightly basic pH (pH 7.3-7.6) (Baize, 2000).

According to the rate of Zihlmann et al. (2019) ($5 < OM < 20$ g.kg^{-1}), soil organic matter levels are low in the soils studied. These low levels of organic matter could be detrimental to soil fertility (Institut Technique Trapical, 2022). This confirms local knowledge of soils and plants that indicate the state of soil poverty. Because it is in the soils under the canopy of poverty indicator plants that the lowest organic matter contents were recorded.

In general, the levels of mineral elements fell slightly in soils under the canopy of poverty indicator plants. This can be explained by the influence of the plant cover, developed on the surface of these soils. And the fall of leaves from this plant cover would influence the speed of mineralization of organic matter.

Thus, in Seguela, the rate of mineralization of organic matter, expressed by the C/N ratio, is lower in poor armored soils with a C/N value around 9. While this value is around 12 in fertile armored soils.

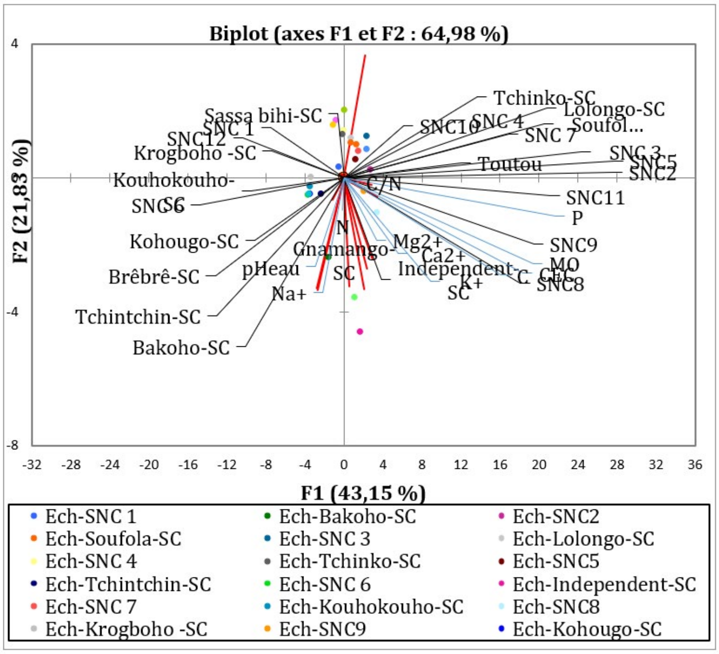

Figure 7: Principal Component Analysis on chemical parameters of soil fertility indicator plants.

This decomposition would be proportional to the plant cover and would depend on the physico-chemical (Alongo et al., 2013; Donfack et Seignobos, 1996) and biological conditions of the soil (FAO, 2021).

The relatively low P content of soils corroborates those of Nignan et al. (2023), which revealed a phosphorus deficiency in soils in sub-Saharan West Africa. But these values are even lower for soils under plants indicating soil poverty, certainly because of the physicochemical and biological conditions.

Seguela soil fertility indicators

It has been observed that farmers use certain ancestral and local knowledge to choose a new plot of land for cultivation. This information is confirmed by the work carried out by Zoma et al. (2023) in Burkina Faso on Endogenous perception of soils. Several studies have clarified farmers' perceptions of the quality of their land, based on their long-acquired knowledge of the indicator value of vegetation or certain signs of the soil or its surface (Maman et al., 2019). This indicator value is based on principles that are also recognised in ecology (Hedde et al., 2015). Farmers in the department of Seguela recognize that fallow land has become fertile again thanks to biological indicators familiar to their environment (Pontanier, 2013). Vegetation is therefore a main indicator of soil fertility, according to farmers. Farmers also know how to name different species in the local language and interpret their presence in a given area, as indicated by Kaboneka et al. (2020). The indicator species for soil fertility in Seguela are *Parinari curatellifolia* (chrysobalanceae), *Terminalia macroptera* (Fabaceae), *Piliostigma thonningu*, *Crossopteryx febrifuga* (Rubiaceae), *Chromonola odorata*. For the latter plant species, the quality of fertility indicator plant has not been established.

On the other hand, infertility indicators are marked by the presence of the following species: *Loudetia arundinacea*, *Maerua anyolensis* (capparaceae), *Gardenia erubescens* (Rubiaceae), *Pericopsis laxiflora* (Fabaceae), *Dichrostachys cinerea* (Fabaceae).

The species defined as bioindicators appear to be sensitive to the high C/N ratio and low pH. They are *Loudetia arundinacea*, *Combretum lecardi*, *Gardenia ternifolia* (Rubiaceae). These plants are indicative of poor soil quality, in line with Adechina et al. (2016). According to these authors, when a soil has a high C/N and a low pH, it is classified as poor soil.

Conclusion

During the soil hardening process, concretions and nodules lead to the formation of blocks of hardpan. They can surface due to erosion and certain human activities.

The resulting plinthic soils may offer agricultural potential due to their physicochemical characteristics, which are several times better than those of generally cultivated, non-hardpan soils. The fertility of these soils can be identified by the abundance of bioindicators such as plant species. These are often well known to local populations.

So, *Parinari curatellifolia* (Chrysobalanceae), *Terminalia macroptera* (Combretaceae), *Terminalia schimperiana* (Combretaceae) and *Piliostigma thonningu* (Fabaceae) are indicator plants for the fertility of cuirassed soils, and *Maerua anyolensis* (Capparaceae), *Trema orientalis* (Cannabaceae), *Gardenia erubescens* (Rubiaceae), *Dichrostachys cinerea* (Fabaceae), *Daniella oliveri* (Fabaceae) are plants that indicate poverty or soil.

This study contributes to the development of land generally marginalized by farmers, thereby reducing pressure on arable land. However, agronomic trials would allow us to assess the behavior of plinthic soils, the fertility of which was established by this study.

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