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Determination of Some Major Physical Characteristics of the Soil at the Jean Lorougnon Guédé Daloa University School-Field and its Suitability for Cultivation

N'GANZOUA Kouamé René[1*]
Département de Pédologie, UFR Agroforesterie
Université Jean Lorougnon Guédé (UJLoG)
BP 150 Daloa, Côte d'Ivoire.

ZADI Florent[2]
Programme riz, Station de recherche de Man
Centre Nationale de Recherche Agronomique (CNRA),
BP 440 Man, Côte d'Ivoire

KOUAME Amany Guillaume[3]
Département de Pédologie, UFR Agroforesterie
Université Jean Lorougnon Guédé (UJLoG)
BP 150 Daloa, Côte d'Ivoire.

ZRO Bi Gohi Ferdinand[4]
Département de Pédologie, UFR Agroforesterie
Université Jean Lorougnon Guédé (UJLoG)
BP 150 Daloa, Côte d'Ivoire.

Abstract:- The study was conducted from mid-May 2022 to June 2022 during the rainy season on the experimental plot of the University Jean Lorougnon Guédé of Daloa (Côte d'Ivoire). The objective was to provide good scientific information on the morphology and the level of physical fertility of the school-field soil for a good agricultural activity. In the field school area, after having determined the azimuthal direction and identified the dominant vegetation, soil pits (100 x 80 x 120 cm) were opened according to the toposequence, at the preferential positions of plateau, slope, mid-slope and lowland, then observed and described. After the soil profiles were described, soil samples were taken from the horizons (surface A and underlying B) at each level of the toposequence to determine the physical parameters. An analysis of variance of the data was performed with SAS 9.4 software and the means were separated using the Newman-Keuls test at the 5% probability level. The results showed that at the morpho pedological level, the field-school soil had a thick superficial A horizon (22 to 32 cm) and a deep underlying B horizon (98 to 88 cm) from the plateau to the lowlands. A plinthitic ferralsol, a plinthitc leptosol, a pseudogleyic ferralsol and a fluviosol were respectively determined along the toposequence. At the physical level, a good particle size fraction was recorded giving a silty-sandy texture of the field-school soil. The average bulk density (1.35 to 1.50 g/cm3) as well as the useful reserve (>100mm) were satisfactory for good soil water circulation. In terms of cultivation suitability, the field-school soil did not present any major constraints to farming. In conclusion, the champ-école soil presented morpho pedological characteristics and physical properties favorable to a good agricultural activity. However, it was noted that the downstream soils (mid-slope and lowland) would be more favorable to food and vegetable crops while the upstream soils (plateau and slope) would be suitable for perennial crops.

Keywords:- *Morpho Pedological Characteristics, Physical Properties, Cultivation Aptitude, Field School, Jean Lorougnon Guédé University Daloa (Côte d'Ivoire).*

I. INTRODUCTION

Soil, because of its complexity and multiple functions, can have several definitions depending on the different fields of application. In its traditional sense, the soil is the natural medium of fixation of plants by their roots from which they draw most of their food for their growth and development [1]. Its morphological organization and physical characteristics ensure the stability of the plant and its survival. It is thus a medium of stability and life, rich in physical properties essential for the plant. In agronomic terms, the notion of agricultural soil refers to the surface layer of the earth, called "topsoil" with an acceptable depth, which the farmer works and maintains in order to grow crops. Although farmers traditionally have a global knowledge of the technical itineraries of cultivated plants, few of them have any knowledge of the physical fertility of the soil before planting crops. In fact, the vast majority of farmers and even actors in development organizations lack scientific knowledge of the physical status of cultivated soils. However, good growth, development and sustainable production of crops depends on a good knowledge of the morpho-pedological and physical characteristics of the soil [2]. This knowledge of the physical characteristics of the soil acquired through the description of the soil profile and the determination of certain properties in the field provides information on the level of physical fertility of the soil. Key physical indicators of soil fertility have been reported by several works, including those of Kouamé and *al.* [3], Adéchina and *al.* [4], Akassimadou and Yao-kouamé [5] and Ouattara [6]. They focused on the morphological characteristics of the different horizons, the proportions of solid soil particles (clays, silts and sands), bulk density and useful reserve. It is therefore to provide a good fixation, a good hydromineral supply, a survival of the plants and even an acceptable agricultural production that this study entitled " Determination of some major physical characteristics of the soil at the Jean Lorougnon Guédé Daloa University school-field and its suitability for cultivation" was initiated. Its main objective is to provide good information on the level of physical fertility of the field-school soil for a good agricultural activity. Specifically, the aim is to describe the morphology of the field school soil and to determine some physical properties. In the medium term, the results of this morpho-pedological characterization will be made available to students for their agronomics tests and to agricultural development organizations to provide support and advice on crop establishment and agricultural production.

II. MATERIALS AND METHODS

➢ *Description of the Study Area*

The study was conducted from May 2021 to June 2022 during the rainy season on an experimental plot at the Jean Lorougnon Guédé University in Daloa. The city of Daloa is the chief town of the administrative region of Haut-Sassandra and the rural development pole of in the Center-West of Côte d'Ivoire located between 6° and 7° North latitude and 7° and 8° West Longitude [7]. The climate is transitional humid tropical with bimodal rainfall ranging between 1200 and 1600 mm/year [8].The average annual temperature is between 24 and 25°C and the average relative humidity is about 70% [9]. The vegetation cover is very heterogeneous and varies progressively from semi-deciduous rainforest to pre-forest savanna. The soils of the region are based on extensive granitic massifs, metamorphic and schistose rocks. They are represented as a Distric plinthic ferralsol complex, which overall have good agricultural suitability for all crop types [10].

➢ *Soil Survey*

The soil survey was carried out using the toposequence method [11]. This method consists of studying the soils that follow one another from the plateau to the lowlands of a morpho-pedological landscape. The pedological prospection work on the site began with the determination, with the help of a compass, of an azimuthal direction, of a northern direction along which a layon was opened

➢ *Floristic Description of the school Field Area*

The dominant vegetation in the field school area was briefly identified and described according to the weed identification guide of Akobundu and Agyakwa [12]. The cropping history was determined by observing the vegetation in place through isolated stands of the previous crop.

➢ *Opening and Description of Soil Pits*

Depending on the toposequence, soil pits measuring 100 x 80 x 120 cm were opened manually in the preferred positions of plateau, slope, mid-slope and lowland. These pits were described according to the criteria defined by the CPCS [13] and inspired by the method of Boulet and *al.* [14], the approach of the Office de Recherche Scientifique et Technique d'Outre-Mer [15] associated with the simplified guide for soil description [16-17-18] and by the soil pit description sheet of the STIPA [19] model adapted to the World reference base for soil resources [20]. These criteria are based on horizon thickness, color, organic matter, moisture, texture, structure, overall cohesion, compactness, porosity, density, root size and abundance, coarse element content, hydromorphy, horizon types, and soil type, among others. In the field, these major soil morphological characters were determined through specific methods summarized in Table 1.

Table 1 Morphological Characterization of the Field-School Soil

Soil Characteristics	**Methods of determination**
Thickness	Measurement of the thickness of the horizon with a tape measure
Color	Munsell code [21]
Organic matter	Assessment of humus content by eye on the face of the soil profile
Hydromorphy	Observation of hydromorphic stains by eye on the face of the soil profile
Porosity	Assessment of pore abundance by naked eye on the face of the soil profile
Compactness	In situ penetration test using a knife [16]
Coarse matter	Estimation of the proportion of gravel by eye on the face of the soil profile
Roots	Assessment of the abundance, size and orientation of roots by eye on the face of the soil profile
Texture	Pudding test [22]
Structure	Observation of the arrangement of soil components

➢ *Determination of Soil Particle Size*

The particle size of a soil defines the proportions of the primary solid particles in the soil. It is determined by measuring the size of the solid particles in the soil that can pass through a sieve with different mesh sizes. Thus, after the description of the soil profile, soil samples were taken from both the A and B horizons at each level of the toposequence (Plateau, Slope, Mid-slope and Lowland) to determine the different proportions of solid particles (clay, silt and sand) of the soil in the laboratory using the sieve method [23]. This method determines the texture of the soil by separating the particle size fractions.

The principle of this sieve method consists of separating a portion of dried soil sample by vibration, on a series of superimposed sieves of different porosities (45 µm, 63 µm, 106 µm, 150 µm, 180 µm, 500 µm, 2 mm and 2.36 mm). After mechanical agitation of the sieve, at a maximum speed of 2000 rpm, for 25 minutes, the granulometric fractions are separated according to their size, in particular, clay (< 45 µm), silt (45 to 60 µm), fine (106-500 µm) and coarse (>2 mm) sands. The contents of each sieve, is subsequently, weighed, and the fraction of sample collected per sieve, is reported on the total amount of sample (in percentage) according to the following equation:

$$Size\ fraction\ (\%) = \frac{Weight\ of\ sieve\ with\ fraction - Weight\ of\ empty\ sieve}{Weight\ of\ the\ total\ sample\ used} X\ 100$$

➤ *Determination of Bulk Density (bd)*

The bulk density is the mass of soil present in a given volume, generally expressed in g/cm3. It reflects the overall compactness of the soil and indirectly, the total porosity and the capacity of water to circulate in the soil. Soil bulk density was determined using the cylinder method [24-25]. A cylinder of 5cm diameter and 10cm length was mechanically driven into the soil. At the desired depth, the cylinder was removed with the soil contained within. This soil sample was oven dried at 105°C for 48 hours and then weighed on an electronic precision balance model NHB-1500 g. The bulk density was obtained by the following ratio:

bd = Mass of dried soil / Volume of cylinder (g/cm3).

The bulk density was calculated for the A and B horizons, considering each level of the toposequence.

➤ *Estimation of the useful Reserve (UR)*

The useful water reserve (UR) of the soil is the necessary quantity of water that a soil can absorb and return to the plant containing a soil. It was determined from the equations of Rawls and Brakensiek [26] considering the values of field capacity (pF 2.5) and soil moisture content at wilting point (pF 4.2). The useful water reserve (UR) is obtained by the equation:

UR = (Moisture pF2.5 - Moisture pF4.2) x z

Where: z = thickness of the horizon in meters

The calculation of the useful reserve was carried out for the A and B horizons considering each level of the toposequence.

➤ *Determination of the Cultural Aptitude of the Field-School Soil*

The cultural aptitude of the soil defines a certain number of physico-chemical parameters giving a possibility of cultivating the soil according to the requirements of the envisaged plant. It was determined from the agricultural limitation according to the thickness of the horizons and the distribution of the gravel on the face of the soil profile [27] at each level of the toposequence (Table 2).

Table 2 Agricultural Limitation due to Chippings and the Depth of the top of the Chippings Layer of the Field-School Soil

		Limitation	
Gravel (% of soil volume)	**Depth of top of rubble layer (cm)**	**Annual plants**	**Perennial plants**
3-15	20-50	None	Low
	50-80	None	None
	80-100	None	None
15-40	20-50	Low	Average
	50-80	None	Low
	80-100	None	None
40-75	20-50	Average	Hygh to very hygh
	50-80	Low	Average
	80-100	None	Faible
> 75	Considered to limit the useful soil in all cases		

➤ *Statistical Processing of the Data*

The data were analyzed using descriptive statistics and analysis of variance (ANOVA) methods using SAS software version 9.4. Means were separated using the Newman and Keuls test at the 5% probability threshold.

III. RESULTS

➤ *Floristic Species of the Field-School Area*

The field-school area of Jean Lorougnon Guédé University is a fallow land of more than twenty years where shrubs and herbaceous plants dominate throughout the toposequence, from the plateau to the lowlands, notably *chromolaena odorata, panicum maximun, impérata cylindrica, aspilia africana*. There are isolated stands of previous perennial crops (coffee, cashew, oil palm) associated with a few trees (iroko, fraké, mango, etc.) as well as food crops (cassava, maize, tomato, eggplant, etc.).

➤ *Morphological Characteristics of Soil Profiles*

The morphologically described open soil profiles along the toposequence (Plateau, Slope, Mid-slope and Lowland) are presented in Fig. 1.

Two main horizons were determined, the A horizon, more superficial and the B horizon, underlying. Overall, we note that the dominant characteristics described are identical with a few differences according to the horizons and the levels of the toposequence.

As for the characteristics of the A horizon, we note that it is humus, porous, loose with subhorizontally oriented roots, a silty-sandy to sandy-clay texture and a lumpy structure regardless of the level of the toposequence. In contrast, thickness, color, hydromorphy, and grit tend to vary with toposequence level. More explicitly, the thickness of the A layer increases with the level of the toposequence.

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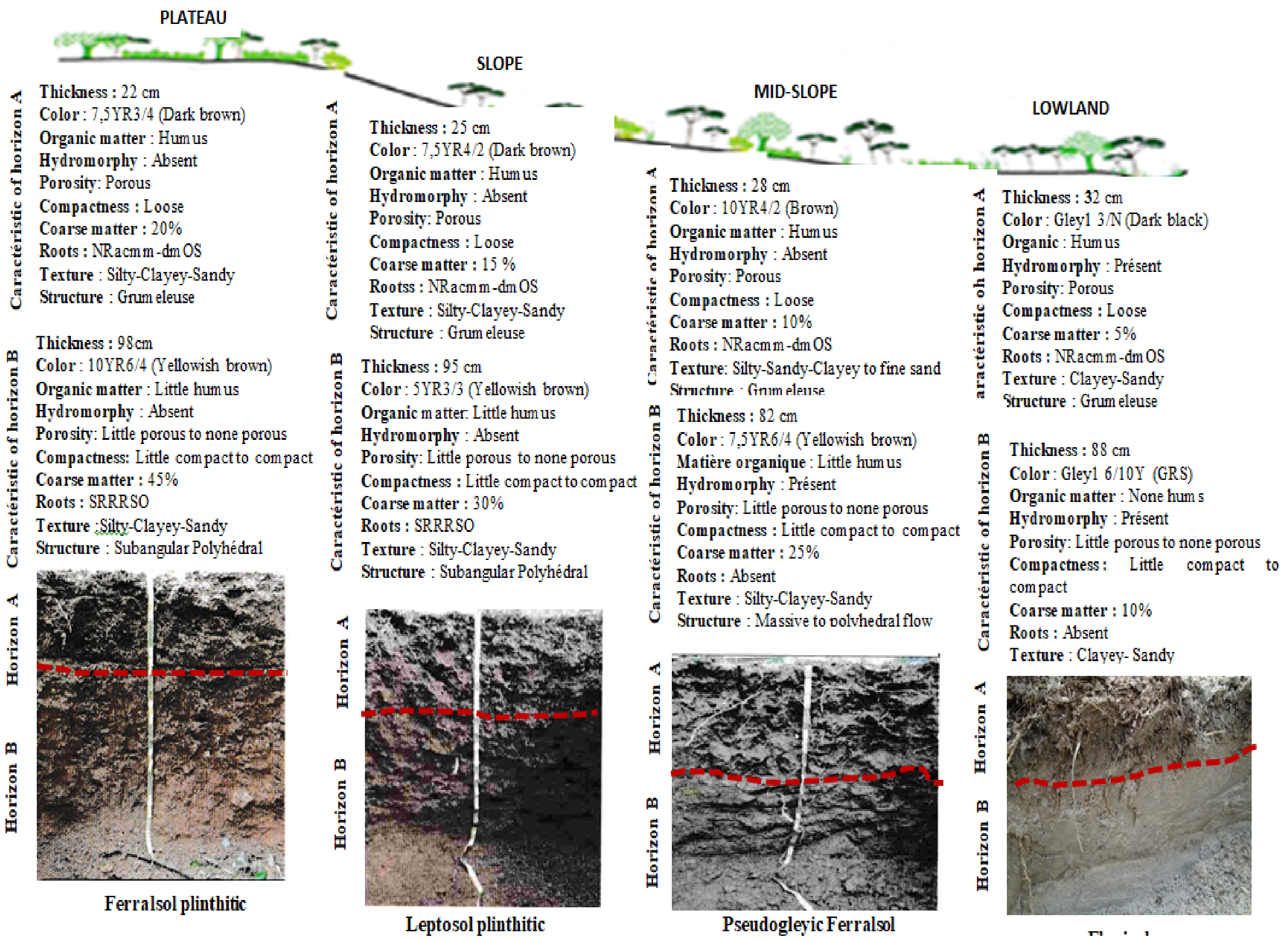
It is thinner on the plateau (22 cm) and on the slope (25 cm), then thicker at mid-slope (28 cm) and in the lowlands (32 cm). Color also varies from dark brown (7.5 YR) on the plateau to dark black (Gley 1, 3/N) in the lowland, and brown (10YR) at mid-slope. Except for the lowland, no hydromorphic stains were observed at the plateau, slope, and mid-slope. The proportion of gravel in the soil decreases with the level of the toposequence. It is 15 to 20% upstream and 5 to 10% downstream.

In terms of the characteristics of the B horizon, a similar description was noted with similarities and dissimilarities. The B layer is thicker at the plateau (98 cm) and slope (95 cm) than at the lowland (88 cm) and mid-slope (82 cm). In addition, the B horizon is almost not humus-bearing, not porous and increasingly compact. A few to sparse roots are observed regardless of the level of the toposequence. The dark brown color changes to yellowish brown (plateau, slope and mid-slope) and to greenish-gray with rust stains in the lowlands. The same is true for the structure, which changes from subangular to massive polyhedral structure with polyhedral flow. The proportion of gravel is higher upstream than downstream. Finally, this morpho pedological description gives a soil type according to the level of the toposequence. There is a plinthitic ferralsol at the plateau, a plinthitic leptosol at the slope, a pseudogleyic ferralsol at mid-slope and a fluvisol at the bottom.



SRRRSO : Some Roots to Rare Root decimetric to centimetric with Subhorizonatal Orientation; GRS : Greenish gray with rusty spots

Fig 1 Morpho Pedological Description of the Different Levels of the Toposequence

➢ *Physical Characteristics of the Soil*

- *Soil Particle Size and Texture*

Table III presents the average content of the different solid particles of the soil (clay, silt and sand) and its texture according to the level of the toposequence, both for the superficial A horizon and the underlying B horizon. His analysis shows that there is a significant difference ($p< 0.05$) between the average contents of the clay and silt soil fractions of the different levels of the toposequence whatever the horizon considered.

The granulometry of the A horizon indicates a much higher clay content (41.90%) in the lowland, low in the mid-slope (15.75%) compared to those of the plateau (25.50%) and the slope (25.67%) which have statistically identical average contents.

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The silt content is low (14.45%) in the lowlands while it is average and statistically equal at the plateau (20.56%), slope (26.75%) and mid-slope (20.53%). For the sand fraction, no significant difference (p >0.05) of the average contents was observed with an average of 54.54%.

As for the granulometry of the B horizon, the contents of the granulometric fractions are similar to those of the A horizon in the same order of variation.

At the level of texture, although relative variations exist between the levels of the toposequences, the overall texture recorded is the silty-clayey-sandy texture (SCS).

- *Soil Bulk Density*

The average bulk densities calculated at each toposequence level in the horizons, superficial A and underlying B are recorded in Table IV. It is noted that no significant difference exists between the average values of bulk density at any level of the toposequence with an overall average between 1.35 and 1.50 g/cm3. Moreover, this apparent density increases relatively when passing from the superficial layer (A) to the underlying layer (B) and this from one level of the toposequence to the other.

- *Soil useful Reserve*

The estimated useful reserves per horizon at each level of the toposequence are recorded in Table V. It is noted that there is no significant difference between the average values of the useful reserve at any level of the toposequence with an overall average above 100 mm. This could translate into a good water retention and circulation capacity of the soil.

- *Soil Cultural Aptitude*

The cultural aptitude of the soil is translated in table VI through the degree of agricultural limitation of the horizons of the field-school soil according to the toposequence.

Table 3 Particle size distribution of the school-field soil horizons according to the toposequence

	Granulometry of horizon A				**Granulometry of horizon B**			
Topographic level	**Clay(%)**	**Silt(%)**	**Sand(%)**	**Texture**	**Clay(%)**	**Silt(%)**	**Sand(%)**	**Texture**
Plateau	25.50b	20.56a	55.94a	SCS	21.75c	21.84a	60.41a	SCS
Slope	25.67b	26.75a	48.75a	SCS	28.00b	26.38a	45.82a	SCS
Mid-slope	15.75c	20.53a	65.75a	SS	19.94c	25.49a	56.26a	SCS
Lowland	41.90a	14.45b	47.45a	CS	38.50a	16.68b	48.63a	CS
Means	**27.20**	**20.57**	**54.54**	**SCS**	**27.04**	**22.60**	**52.80**	**SCS**
Pr > F	0.042	0.057	0.622	-	0.059	0.056	0.755	_

Values followed by the same letter in the column are not statistically different at the α = 0.05 threshold.
SCS = Silty-Clayey-Sandy; SS = Silty-Sandy; CS = Clayey-Sandy

Table 4 Bulk Density of School-Field Soil Horizons as a Function of Toposequence

	Topographic level				
Bulk density (g/cm^3)	**Plateau**	**Slope**	**Mid-slope**	**Lowland**	**Norms***
bd-horizon A	1.4a	1.3a	1.4a	1.4a	-
bd-horizon B	1.5a	1.4a	1.5a	1.6a	-
Means	**1.45**	**1.35**	**1.45**	**1.50**	**1.30-1.70**
Pr > F	0.588	0.685	0.156	0.253	-

Values followed by the same letter are not statistically different at the α = 0.05 threshold; *Normative reference values [28]

The overall analysis of the table shows that the superficial layer A and even the underlying layer B do not constitute a major constraint to the agricultural practice of annual and perennial plants if the depth and distribution of the rubble in the soil are taken into account. The soil of the training field is therefore considered to be very suitable for agriculture considered to be very suitable for agriculture.

IV. DISCUSSION

➢ *Morphopedological Characteristics of the Field-School Soil*

The description of the morphological characteristics was based on the 120 cm deep soil profiles carried out at different levels of the toposequence (plateau, slope, mid-slope and lowland) without encountering major constraints likely to hinder the establishment of an agricultural activity. This indicates a deep character of the field-school soil. The depth of the soil is one of the most important morphological characteristics for identifying the soil type. Indeed, according to the work of Boyer [30] and Wambeke [31], a soil deeper than 120 cm is qualified as ferralsol [22].

This makes us say that the soil of the school field is a Ferralsol. Due to the reworked, indurated reworked character and the presence of more or less hydromorphic stains in the soil profiles, the soil types Ferralsol plinthitic (plateau), Leptosol plinthitic (slope), pseudogleyic ferralsol (mid-slope) and fluvisol (lowland) correspond to the WRB world soil classification [20]. In addition, the soil profiles of the school field are characterized by high organic matter content in the top 30 cm of soil. This high organic matter content would be due to the fact that the school-field area is a fallow of more than twenty years having produced an abundant biomass on the soil [32-33].This abundant organic matter would confer to the school-field soil nutrients necessary for crops through humification and mineralization processes, and consequently the improvement of its fertility [34-35-36].

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The soil in the field-school profile exhibited a lumpy to polyhedral subangular lumpy structure and a silty-sandy to sandy-clay texture along the profile on the surface A and underlying B horizon. These characteristics show that these soils have a very good potential for crop development. Indeed, a lumpy structure and a sandy-clay texture have been shown to be the best structures and textures that offer favorable properties for rooting and plant development [37]. Also, the relatively low proportions of coarse elements in the depths of the soil would facilitate the root penetration of plants. This could explain the presence and abundance of roots in these horizons.

Table 5 Useful Reserve of the Horizons of the Field-School Soil According to the Toposequence

	Topographic level				
Useful reserve (mm/cm)	**Plateau**	**Slope**	**Mid-Slope**	**Lowland**	**Norms***
UR-horizon A	126a	115a	114a	137a	52.4-60.2
UR-horizon B	123a	111a	100a	140a	37.7-73.4
Means	**124.5**	**113**	**107**	**138,5**	**47.7-66.46**
Pr > F	0.641	0.512	0.438	0.389	-

Values followed by the same letter are not statistically different at the α = 0.05 threshold; *Normative reference values [29]

Table 6 Degree of Agricultural Limitation of the School-Field Soil Horizons According to the Toposequence

<table>
<tr><td></td><td colspan="6">Degree of agricultural limitation of horizon A</td><td colspan="5">Degree of agricultural limitation of horizon B</td></tr>
<tr><td></td><td></td><td colspan="4">Topographic level</td><td></td><td colspan="5">Topographic level</td></tr>
<tr><td></td><td></td><td>Plateau</td><td>Slope</td><td>Mid-slope</td><td>Lowland</td><td>Norms*</td><td>Plateau</td><td>Slope</td><td>Mid-slope</td><td>Lowland</td><td>Norms*</td></tr>
<tr><td></td><td>Deph (cm)</td><td>22</td><td>25</td><td>28</td><td>32</td><td>20-50</td><td>98</td><td>95</td><td>82</td><td>88</td><td>80-100</td></tr>
<tr><td></td><td>Gravel (%)</td><td>20</td><td>15</td><td>10</td><td>5</td><td>3
<15<40</td><td>45</td><td>30</td><td>25</td><td>10</td><td>15
<40<75</td></tr>
<tr><td rowspan="2">Crop group</td><td>Annual plants</td><td>Low</td><td>Low</td><td>None</td><td>None</td><td>-</td><td>None</td><td>None</td><td>None</td><td>None</td><td>-</td></tr>
<tr><td>Perennial plants</td><td>Average</td><td>Average</td><td>Low</td><td>Low</td><td>-</td><td>Low</td><td>None</td><td>None</td><td>None</td><td>-</td></tr>
</table>

*Normative Reference Values [27]

Finally, the soil of the Jean Lorougnon Guédé University field school presented morphologically and physically favorable characteristics overall for all types of crops.

➢ *Physical Properties of the Field School Soil*

The granulometric fractions of the superficial A and subjacent B horizons of the field-school soil present, from the point of view of their physical properties, a relatively balanced texture, of a mainly sandy-clayey nature. Indeed, all three granulometric fractions (clay, silt and sand) are generally well represented, whatever the level of the toposequence. This gives them good agronomic potential according to the work of Tossou and *al*. [38] in the agricultural areas of the Abomey-Bohicon conurbation in Benin. However, the granulometric fraction is predominantly sandy throughout the toposequence. This could be due, in part, to the water erosion observed at the plateau level and the progressive silting of the other levels of the toposequence. The silty-sandy texture is indicative of a balanced texture that is favorable for cultivated plants. This would be an advantage for crop adaptation. This result confirms the work conducted by Buol and *al*. [39] and Pypers et al. [40] who showed that the clay-sand soil texture is excellent and suitable for most crops for good yield.

The field-school soil recorded an average bulk density that ranged from 1.35 to 1.50g/cm3. These values correspond to the standard bulk density of Ferrasols ranging from 1.30 to 1.70g/cm3 according to Bitom [28]. This apparent density of the soil would be due to the abundance of fine clay particles that compact and densify the material [41]. Furthermore, the bulk density increases from the more superficial A horizon to the underlying B horizon. This result corroborates the work of Kouadio and *al*. [42] stating that bulk density is low in the upper horizons compared to the lower horizons. The low bulk density in the (A) horizon at the surface is the sense that porosity is higher in this horizon than in the deeper horizons [43].

The useful soil reserve recorded is high (> 100 mm) constituting a good water reserve in the soil for hydromineral nutrition of the plant [29]. This good water retention capacity of the field-school soil would result from its granulometric composition and its silty-sandy texture [44], its good arrangement in a lumpy structure with a subangular polyhedral tendency [45]. These properties provide the soil with sufficient porosity to facilitate water flow in the soil interstices to store water for roots [46] and also to absorb it by suction [47].

V. CONCLUSION

The study conducted on the experimental plot of the Jean Lorougnon Guédé University of Daloa aimed to determine its morphological and physical characteristics and its cultivation suitability in order to predict a good agricultural activity. The morphological characteristics and physical properties of the field-school soil revealed a ferralsol type soil, deep, with no major constraints, a silty-clay-sandy texture, a lumpy to polyhedral anbangular structure, a convincing apparent density and a good useful

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reserve for plants. These different characteristics give the field-school soil of the University Jean Lourougnon Guédé Daloa (Côte d'Ivoire) a good aptitude for all kinds of crops, perennial, food and market gardening. This result is made available to students and teacher-researchers

➢ *Competing Interests*

Authors have declared that no competing interests exist.

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