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Characteristics of soil exchangeable potassium according to soil color and landscape in Ferralsols environment

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Abstract: The use of soil color as Munsell data was explored for *in situ* indication of soil potassium (K) availability toward a friendly method of agricultural land survey. Soil contents of K, calcium, and magnesium were determined for 998 upland soil samples from Côte d'Ivoire (7–10°N). Soil depths (0–20, 20–60, 60–80, and 80–150 cm), redness ratio (RR), and redness factor (RF) were considered. Significant association was observed between K-levels (high, medium, and low) in topsoil and its color hue, and the highest cumulative frequency of 2.5YR in high and medium levels was characterizing the hill slope position (summit and upper slope). Deep horizon, foot slope, and yellowish color (7.5YR and 10YR) were more relevant to low K-level. Significant linear regressions of soil content of K were observed according to both redness indices indifferently to the topographic positions and soil depths in some extend. Of these finding in the line of folk knowledge, RR and RF are recommended for *in situ* measurement of soil K, and 2.5YR as color hue may be use as indicator of K-enriched soil at hill slope position.

Subjects: Earth Sciences; Environment & Agriculture; Environmental Studies & Management

Keywords: indicator of soil fertility; potassium; catena; soil color; folk knowledge

ABOUT THE AUTHORS

The data reported in the current paper were drawn from the thesis of Brahima Koné as first author. The work was carried out in Côte d'Ivoire in order to develop a tool for soil survey in Ferralsol environment. The co-authors of current paper have contributed to data analysis and interpretation as well as for the writing of the manuscript.

PUBLIC INTEREST STATEMENT

Soil use and management are important factors affecting agricultural production, while conventional standard methods of soil assessment are not well understood, especially by non-educated farmers of tropical Africa. In contrast, there were social and economical perceptions of farming including the land use as long as populations are practicing agriculture. So call folk knowledge, local populations around the word have friendly methods of soil classification in relation with its fertility and productivity. The soil color accounts for criteria in folk knowledge. Regarding to the importance of soil content of potassium in Ferralsol, the current study emphasized the relation between soil content of this nutrient and soil color in interaction with the topographic position of landscapes. The hill slope position characterized by reddish soils was found to be the most enriched land in potassium.

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1. Introduction

Sustaining agriculture requires sound soil evaluation methods in concordance with morphopedology standards (Bertrand et al., 1985; Loukili et al., 2000). However, minimum data-set requirements are differing according to authors: soil attributes or both soil and plant parameters may be concerned (Larson and Pierce, 1991; Pearson et al., 1995; Pieri, 1992). This variance in methodology as a weakness was tackled by Riquier et al. (1970) when initiating the use of soil productivity index which was improved with data relevant to crop potential yielding (root development) as function of soil environment (Burger, 1996; Gale et al., 1991; Kiniry et al., 1983; Milner et al., 1996; Pierce et al., 1983). In the meantime, ecological specificity was considered by including soil contents of phosphorus (P) and organic matter (Neill, 1979) and typical model was suggested for tropical environment (Sys and Frankart, 1971). Of existing models, soil content of potassium (K) was missing as parameter though; this nutrient is among the most limiting of crop growth in tropical agro-ecologies (Koné, Fatogoma, Chérif, 2013).

The most recent approach of soil management is the fertility capability classification (FCC) system (Sanchez et al., 2003) based on five data-sets of soil as modifiers including soil content of K. However, this system is not popularly adopted yet. The wide number of required parameters, specially the chemical analytical data and the skill required for FCC may be of concerned. Therefore, a friendly method of soil chemical parameters estimation in field can contribute to wide adoption of such fertility classification of soil. For this purpose, the color of soil as a component of folk classification (Krasilnikov & Tabor, 2003), may have consistent contribution as friendly prediction method of Ferralsols K availability.

In fact, there is evidence of Ferralsols inherent fertility classification as poor for yellow and richer for reddish colors at a given topographic position, especially for soil contents of P, K, and magnesium (Mg) in addition to soil particle sizes (Koné, Yao-Kouamé, et al., 2009). Moreover, the opportunity of soil K supplying capacity was successfully explored using soil color by Koné, Bongoua-Devisme, Kouadio, Kouadio, and Traoré (2014).

Indeed, the colors of Ferralsols are relevant to difference in their mineralogy, organic matter content, and texture (Koné, Diatta, et al., 2009; Stoner et al., 1980) as major descriptors of their history.

The use of soil redness (Torrent et al., 1980, 1983; Santana, 1984) for estimating soil K availability on the basis of linear regression may be a fast and cheapest method, hence limiting constraint in agricultural soil capacity evaluation where soil content of K may be critical.

Soil survey was conducted in Côte d'Ivoire above the latitude 7°N applying randomized and unequal stratified soil sampling method. Soil color was determined by Munsell chart and soil exchangeable K was analyzed for exploring the accuracy of soil redness rate (RR) and redness factor (RF) in a linear regression of soil K. The aim was (i) to identify a soil color hue for a given level (high, medium, and low) of soil K in spatial distribution according to soil depth and topographic section, (ii) to defined the relation between soil exchangeable K and soil color, and (iii) to identify fit model of soil K among that using RR and RF. Definitively, a model of soil exchangeable K content should be recommended for landscape section and soil depth as a tool for most friendly method of soil survey.

2. Material and methods

2.1. Studied zone description

The study was carried out across 19 sites characterized by Ferralsols encountered between the latitudes 7–10°N in Côte d'Ivoire. Four major agro-ecologies were described in there by Koné (2007) as Sudan savannah with grassland, Guinea savannah with woodland, derived savannah (a transition between savannah and forest agro-ecologies), and mountainous zone located in the west of the country. Annual average rainfall amount ranged from 1,200 to 2,000 mm.

Dismantled or unaffected summit (SUM) ferruginous cuirass of plateau landscapes further characterized by slightly concave or convex sides were frequently encountered in the studied area beside of hills with bedrock outcroppings. A few inselbergs were also observed and, the landside and length of landscapes were variable accordingly. Upland soils were essentially Ferralsols plinthic belonging to hyperdystric or dystric groups.

2.2. Soil sampling

Two hundred and eighty-nine soil profiles were surveyed along the toposequences of various landscapes at 19 sites. The soil profiles were unequally distributed (Webster and Oliver, 1990) on three sub-groups of Ferralsols encountered in the studied area (Koné, Diatta, et al., 2009). The identified horizons in the soil profiles were coded according to depth classes—H1 (0–20 cm), H2 (20–60 cm), H3 (60–80 cm), and H4 (80–150 cm) dividing the soil profile into organic horizon (Diatta, 1996), minimum, medium, and maximum crop rooting depths (Böhn, 1976; Chopart, 1985), respectively. A total of 995 samples (2 kg for each) were taken from soil horizons up to a maximum depth of 1.5 m when possible (Table 1).

2.3. Soil sample characteristics

Soil sample size of a given color hue was variable according to soil depth across the studied zone.

The corresponding numbers of soil samples were 274, 325, 279, and 117 for the SUM, upper slope (US), middle slope (MS), and foot slope (FS), respectively.

2.4. Laboratory analysis and classification of soil K contents

Soil samples were dried under forced air at room temperature. Then, they were crushed before sieving through a 2.0-mm stainless steel sieve. Exchangeable K of soil was extracted by shaking 1 g in 10 ml of 1 M NH4OAc during 5 min before the use of atomic emission in a Perkin Elmer Analyst 100 spectrometer (Page, 1982). Three classes of soil contents of exchangeable K were defined as done by Berryman et al. (1984) for tropical soils:

L = Low soil content of K ranging below 0.15 cmol kg^{-1}.

M = Moderate soil content of K ranging between 0.15 and 0.30 cmol kg^{-1}.

H = High soil content of K ranging over 0.30 cmol kg^{-1}.

Soil contents of calcium (Ca) and Mg were also analyzed using the same extraction method described above.

2.5. Soil color identification

The year 2000 revised washable edition of Munsell soil color charts (Gretagmacьeth, 2000) composed of 322 different standard color ships was used in field during the survey for soil color identification. Wet soil samples were compared with the standard color ships, respectively, and the three components of the color were recorded as “Hue (He); Chroma (*C*)/Value (*V*).” The RF defined as RF by Santana (1984) was calculated for each of the soil samples likewise the redness ratio (RR) according to Torrent et al. (1980, 1983):

Table 1. Soil sample size of a given soil color hue as identified in soil depths

	Number of soil sample				
	H1	**H2**	**H3**	**H4**	**Total**
2.5YR	77	94	68	54	293
5YR	121	134	86	46	387
7.5YR	81	74	35	16	206
10YR	40	36	18	15	109
Total	319	338	207	131	995

$$RF = (10 - He) + C/V \tag{1}$$

$$RR = (10 - He) \times C/V \tag{2}$$

2.6. Statistical analysis

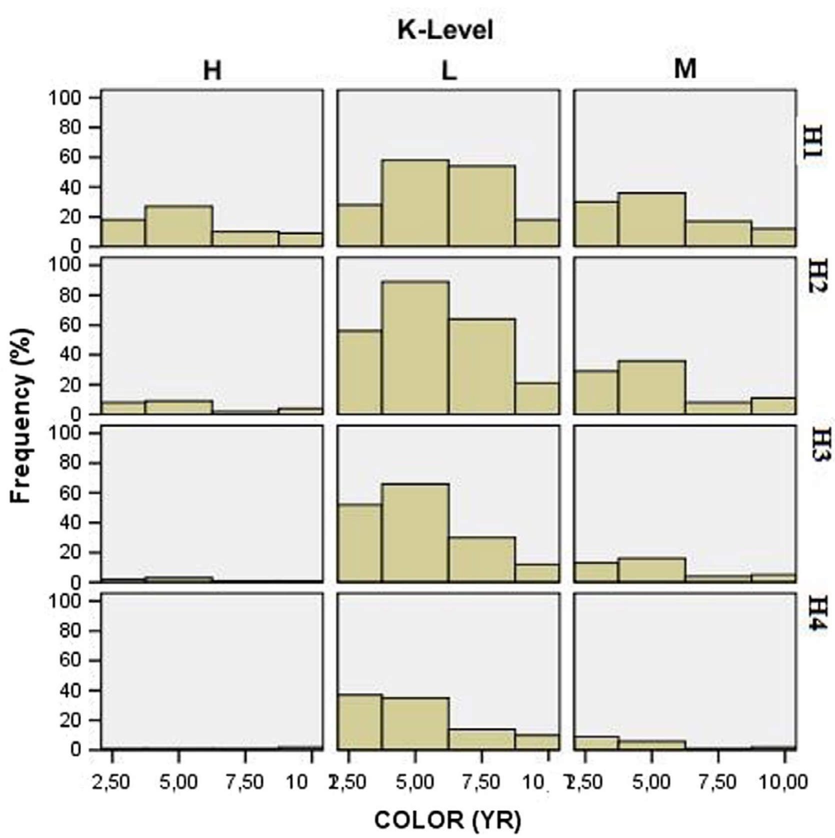
By descriptive analysis, average frequency of soil content of exchangeable K was determined in topsoil (H1 and H2) for each topographic section (S, US, MS, and FS) and for each soil color hue as encountered (2.5, 5, 7.5, and 10YR) using SPSS 10 package. Cross-table analysis was done to determine the frequency of soil K levels (H = high, M = moderate, and L = low) according to soil depths (H1, H2, H3, and H4) and the topographic sections for the identified soil color hue. Pearson correlation analysis was also performed between RR and soil contents of K, Ca, and Mg and likely for RF, respectively. Furthermore, soil content of exchangeable K was predicted by RR and RF separately using linear regression analysis step by step with constant term or not, and the most significant ($p < 0.05$) model was reported. The thickness of elementary soil horizon was considered as weighted variable. SAS (version 8) was used for these statistical analyses and the critical level of probability was fixed as 0.05 (α).

3. Results

3.1. Characterization of soil K levels

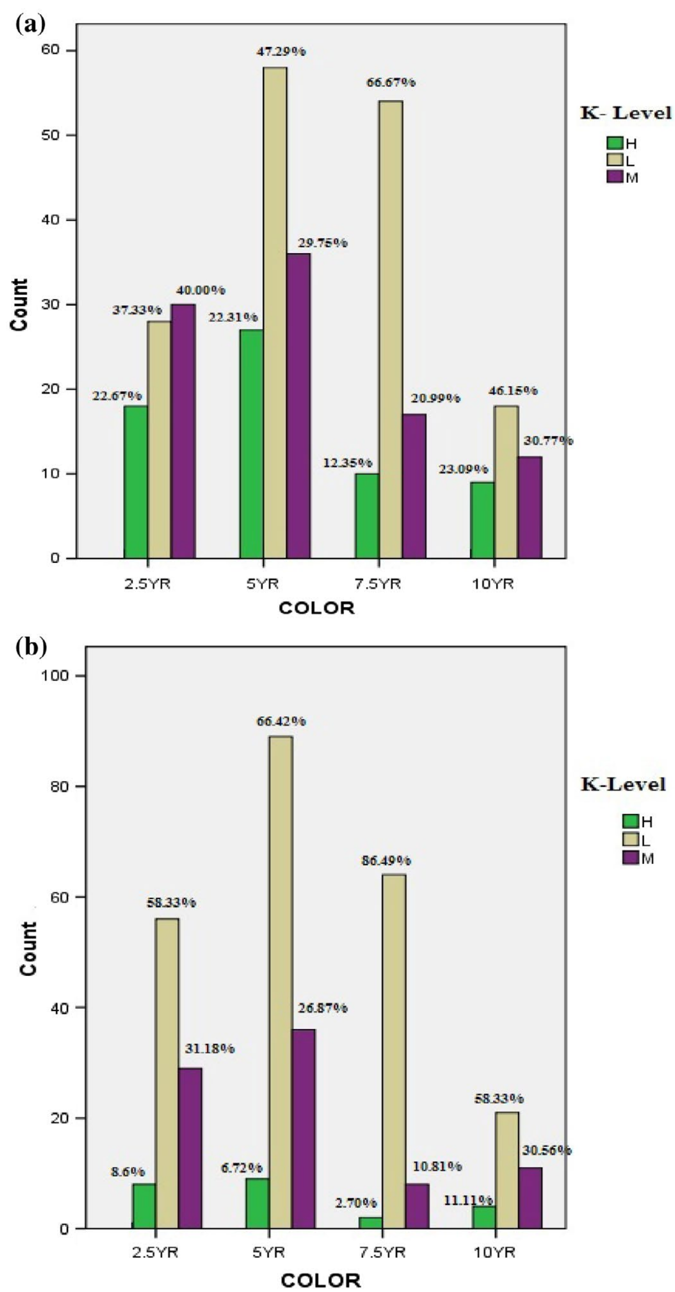
The frequencies of soil color hues (2.5, 5, 7.5, and 10YR) as determined for different soil depths (H1, H2, H3, and H4) according to K-levels are presented in Figure 1. The highest frequencies are related to the low K-level (L) throughout the soil profile with outstanding values for 5 and 7.5YR in the topsoil layers (H1 and H2), while similarly observed for 2.5 and 7.5YR in the subsoil (H3 and H4). Nevertheless, the highest cumulative frequencies of 2.5YR in medium (M) and high (H) levels of soil K is observed likewise for 5YR as soil color hue.

Figure 1. Frequency of soil potassium levels (H, M, and L) according encountered Munsell color hues (2.5, 5, 7.5, and 10YR) in different soil depths (H1, H2, H3, and H4).



In fact, there are 40, 37.3, and 22.6% of chance to observed 2.5YR as soil color hue in topsoil 0–20 cm for medium, low, and high soil K-levels, respectively (Figure 2a). Hence, the cumulative frequency of 2.5YR referring to medium and high K-levels is about 62.67% over the occurrence as low K-level. Similar results also account for the soil samples of 5YR (52.06% vs. 47.29%) and 10YR (53.15% vs. 46.15%) in color hues contrasting with the results observed for 7.5YR. Further contrast is observed in 20–60 cm soil depth showing the highest frequencies of low K-level (L) compared to the cumulative frequency (high (H) and medium (M) K-levels) indifferently to soil color (Figure 2b).

Figure 2. Frequency of potassium level in H1 (a) and H2 (b) according to encountered Munsell color hue (2.5, 5, 7.5, and 10YR).



More details of these results are presented in Figure 3 considering the topographic positions. The soils colored in 2.5YR are outstanding with the highest frequencies of K-levels in both soil depths (0–20 and 20–60 cm) at the SUM position, while similar observations account for 5, 7.5, and 10YR at the US, MS, and FS positions, respectively (Figure 3a): highest cumulative frequency of 2.5 YR in H and M levels of soil K is characterized by the soil samples of SUM and US, while almost equal chances are observed between this cumulative frequency and that related to L when referring to a soil sampled at US with 5YR in color. In turn, the highest frequencies characterizing the soils of 7.5 and 10YR in L are observed when sampled in 0–20 cm at MS and FS positions, respectively. Highest frequencies of L are also observed in 20–60 cm depth indifferently to soil color and topographic section even when compared with the cumulative frequency relative to H and M (Figure 3b). Hence, reddish (2.5YR) topsoil (0–20 cm) appeared to be most enriched (H and M) in exchangeable K, especially for the SUM and UP positions.

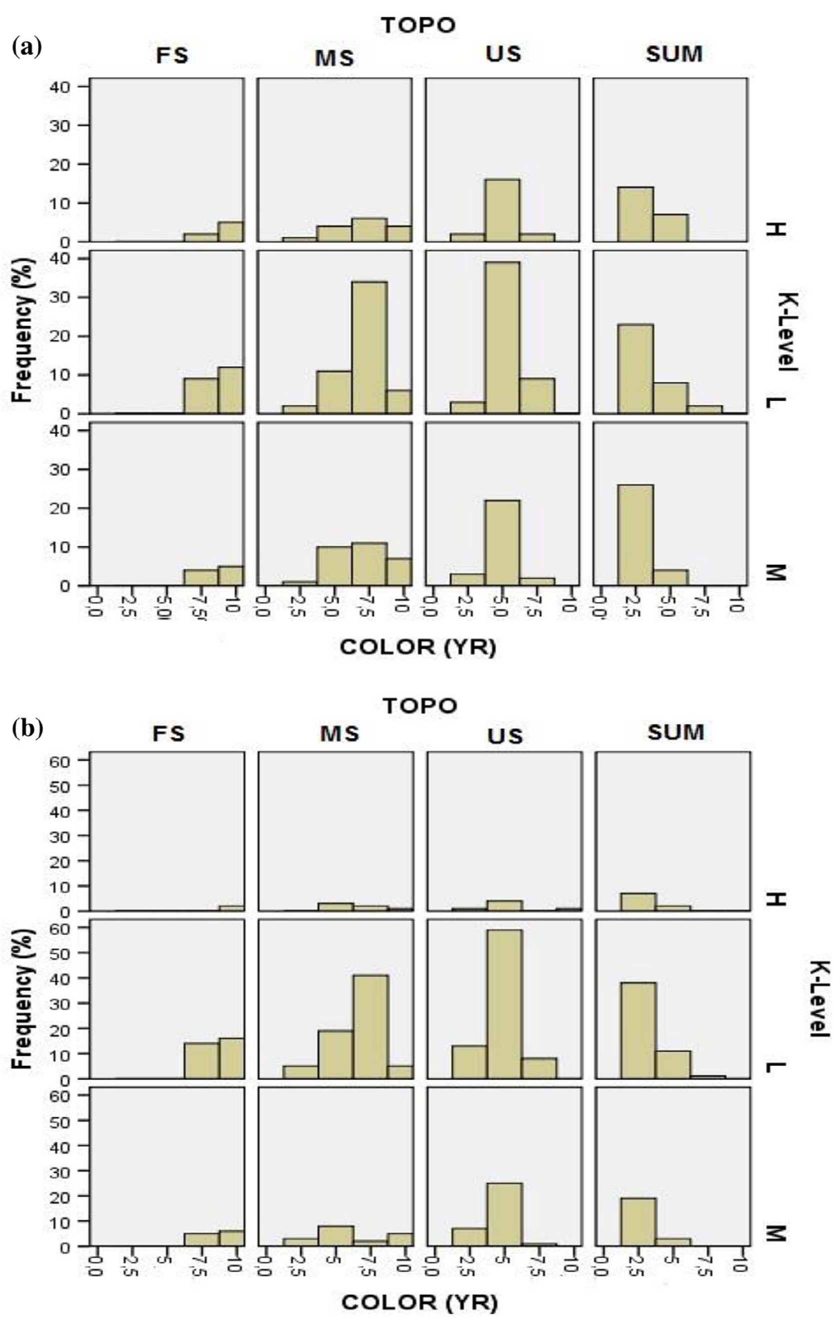


Figure 3. Frequency of potassium level in H1 (a) and H2 (b) depth according to topographic section (TOPO) and encountered Munsell color hue (2.5, 5, 7.5, and 10YR).

Table 2. Frequency of soil color hue as associated to soil K-level (H, M, and L) in 0–20 cm soil depth at different topographic positions

		Frequency (%)		
		H	M	L
Summit	2.5YR	22.22	41.27	36.51
	5YR	36.84	21.05	42.11
	7.5YR	0.00	0.00	100
	10YR	0.00	0.00	0.00
χ^2 probability				0.521
Upper slope	2.5YR	25.00	37.50	37.50
	5YR	20.78	28.57	50.65
	7.5YR	15.38	15.38	69.24
	10YR	0.00	0.00	0.00
χ^2 probability				0.054
Middle slope	2.5YR	25.00	25.00	50.00
	5YR	16.00	40.00	44.00
	7.5YR	11.00	21.57	66.43
	10YR	23.53	41.17	35.30
χ^2 probability				0.298
Foot slope	2.5YR	0.00	0.00	0.00
	5YR	0.00	0.00	0.00
	7.5YR	13.33	26.67	60.00
	10YR	22.73	22.73	54.56
χ^2 probability				0.412

These observations are strengthened by crossing case occurrences according to the topographic sections and soil color hues as determined in the topsoil 0–20 cm soil depth (Table 2): although not always significant, the highest frequencies of reddish soils are accounting for H and M levels of K at the SUM, US, and MS. Greater cumulative frequency of reddish soil relative to H and M levels of soil K is characterizing the S and US when compared to that of L. Arguably, soil K-level of L is more associated to 7.5 and 10YR at FS position of landscape.

3.2. Relationship between soil cations and the redness of soil

Tables 3 and 4 are showing the relations (correlation coefficient) between soil contents of cations and its redness referring to the RR and the RF, respectively. Except the negatives correlation coefficients observed in 80–150 cm at the SUM (−0.48) and 20–60 cm at the FS (−0.27), no significant relation is noticed between soil content of K and RR (Table 3). This statement is contrasting with the positive correlations observed for soil contents of Mg in 20–60 cm (R = 0.22; p = 0.020) and 60–80 cm (R = 0.22; p = 0.09) depths at MS position. Significant (p = 0.040) correlation between soil content of Ca and RR only accounts for 20–60 cm soil depth at foot slope. No significant correlation accounts for the topsoil (0–20 cm) indifferently to soil contents of cations and topographic sections. Overall, almost the significant correlations are observed in 20–60 cm depth at down slope (MS and FS) of landscape involving all the studied cations. In some extend, similar results are observed in Table 4 relative to the correlation between RF and soil contents of cations (K, Ca, and Mg).

Table 3. Correlation between soil contents of cations (K, Ca, and Mg) and its (RR) in soil depths according to topographic sections

		Pearson correlation for RR							
		0–20 cm		20–60 cm		60–80 cm		80–150 cm	
		R	***p*-value**	***R***	***p*-value**	***R***	***p*-value**	***R***	***p*-value**
SUM	K	−0.14	0.199	0.02	0.828	−0.10	0.460	−0.48	0.001
	Ca	−0.12	0.272	0.04	0.689	−0.10	0.440	−0.003	0.818
	Mg	0.006	0.981	−0.14	0.218	−0.08	0.535	−0.22	0.127
US	K	−0.003	0.975	−0.08	0.344	−0.09	0.426	0.22	0.195
	Ca	0.020	0.837	0.03	0.747	0.009	0.961	0.07	0.666
	Mg	0.010	0.310	−0.003	0.967	−0.000	0.996	0.000	0.995
MS	K	0.01	0.877	−0.03	0.742	−0.025	0.851	−0.24	0.189
	Ca	0.008	0.931	0.14	0.828	−0.04	0.722	0.02	0.909
	Mg	−0.02	0.845	0.22	0.020	0.22	0.09	−0.04	0.789
FS	K	−0.14	0.398	−0.27	0.060	−0.17	0.404	−0.30	0.399
	Ca	−0.03	0.644	0.30	0.040	0.09	0.648	−0.07	0.822
	Mg	0.03	0.831	0.24	0.126	−0.02	0.922	−0.09	0.791

Table 4. Correlation between soil contents of cations (K, Ca, and Mg) and its redness factor (RF) in soil depths according to topographic sections

		Pearson correlation for RF							
		0–20 cm		20–60 cm		60–80 cm		80–150 cm	
		R	***p*-value**	***R***	***p*-value**	***R***	***p*-value**	***R***	***p*-value**
SUM	K	0.06	0.560	0.07	0.497	−0.11	0.112	−0.54	0.0002
	Ca	−0.04	0.653	0.13	0.227	0.02	0.861	0.03	0.811
	Mg	0.06	0.535	0.05	0.627	0.035	0.790	−0.09	0.503
US	K	0.06	0.50	−0.06	0.459	−0.09	0.455	0.30	0.070
	Ca	−0.01	0.862	0.04	0.612	0.005	0.961	0.15	0.342
	Mg	0.09	0.329	0.05	0.585	−0.000	0.998	0.08	0.617
MS	K	0.01	0.870	−0.02	0.828	0.08	0.548	−0.29	0.105
	Ca	−0.02	0.831	0.22	0.030	0.05	0.692	0.007	0.967
	Mg	−0.09	0.341	0.29	0.004	0.27	0.044	−0.06	0.729
FS	K	−0.19	0.260	−0.17	0.255	−0.12	0.542	−0.13	0.699
	Ca	−0.10	0.844	0.31	0.044	0.13	0.529	0.04	0.898
	Mg	0.036	0.830	0.32	0.038	−0.04	0.835	−0.08	0.808

However, significant ($p < 0.0001$) linear regressions of soil content of K are observed according to RR and RF, respectively, except the soil sampled at 80–150 cm depth at middle (RF and RR) and foot (RR) slope positions (Table 5). The coefficients of these regressions are low (1/100 times) and characterized by an increasing trend with soil depth indifferently to the descriptive variables.

Table 5. Linear regression of soil exchangeable K according to RF and RR, respectively, according to topographic sections and soil depth

		Linear regression of soil K											
		0–20 cm			20–60 cm			60–80 cm			80–150 cm		
		Coef.	*p*-value	Err.	Coef.	*p*-value	Err.	Coef.	*p*-value	Err.	Coef.	*p*-value	Err.
SUM	RF	0.03	<0.0001	0.003	0.02	<0.0001	0.02	0.01	<0.0001	0.001	0.02	<0.0001	0.003
	RR	0.02	<0.0001	0.002	0.01	<0.0001	0.001	0.01	<0.0001	0.001	0.01	<0.0001	0.002
US	RF	0.05	<0.0001	0.004	0.02	<0.0001	0.024	0.01	<0.0001	0.001	0.01	<0.0001	0.001
	RR	0.04	<0.0001	0.004	0.02	<0.0001	0.001	0.01	<0.0001	0.001	0.01	<0.0001	0.001
MS	RF	0.05	<0.001	0.008	0.03	<0.0001	0.004	0.02	<0.0001	0.003	0.03	0.500	0.05
	RR	0.05	<0.0001	0.009	0.02	<0.0001	0.003	0.02	<0.0001	0.003	0.02	0.711	0.046
FS	RF	0.09	0.08	0.05	0.05	<0.0001	0.005	0.04	0.001	0.011	0.04	0.030	0.01
	RR	0.08	0.38	0.09	0.04	0.009	0.01	0.03	0.06	0.01	0.02	0.366	0.02

4. Discussion

4.1. Soil K appraisal by landscape and soil color

There was more evidence for identification of the soils characterized by low K-level using soil color across the surveyed area: deepest horizon, the FS position of landscape, and the soil color of 10YR (very pale brown-yellow–dark yellowish brown) were fund to be more relevant to this finding. The release of K by organic matters as surface K-source combined with a relative poor (vs. Na) mobility of this nutrient (Hem, 1992) and the downward gradient of bed rock weathering as inner source of K (Wedpohl, 1978) may account for this.

In turn, high and medium levels of soil K were often observed at the SUM and UP positions and characterized by 2.5YR (pink–red) as soil color hues, especially in the topsoil. However, there is chance to observed a variance of this result according to the landscape variability in the studied area somewhere including inselbergs and plateau with outcrop bedrocks (Eschenbrenner and Badarello, 1978; Poss, 1982): of course, encountered young soil (e.g. Regosols) with shallow depth (<40 cm) may have high level of K though, the color hue may range between 7.5 and 10YR. In fact, these yellowish colors are characterized by goethite (α-FeOOH) preceding the reddish soil matrix of lepidocrocite (γ-FeOOH) and hematite (α-Fe_2O_3) in the course of soil development (Buxbaum and Printzen, 1998; Schwertmann, 1985). As young soil, enriched-K parental material (e.g. feldspar and mica) may have influence in soil composition (Nahon, 1991). When excluding similar cases, reddish soil color hue of 2.5YR at the hill slope (SUM and US) is somewhat a consistent environmental indicator of enriched soil in exchangeable K. However, the occurrence of 2.5YR as soil color was found to be limited in topsoil and FS because of vertical and lateral gradients of tropical soil color (Koné, Yao-Kouamé, et al., 2009). Definitively, enriched soils in K are more limited in the UP position than the SUM on the basis of the highest cumulative frequency of 2.5YR in H and M levels of soil K and the lateral gradient of soil color.

Furthermore, the red pigmentation (e.g. Hematite) of 2.5YR is deriving from ferrihydrate (Schwertmann, 1985) requiring edaphic conditions which may include high temperature, low water activity, low organic matter content, nearly neutral pH, and high contents of Ca and Mg contrasting with the optimum conditions of goethite formation for yellowish pigmentation (Torrent & Barron, 2002). Almost these parameters involved in soil pigmentation are also accounting for major chemical modifiers of fertility capability soil classifications (FCC) defined by Sanchez et al. (2003) emphasizing an opportunity to make easier the adoption this classification system.

Indeed, degraded Ferralsols are richer in coarse particle with dominance of yellow pigmentation coupled with low content of soil exchangeable K even for enriched bedrock K-primary mineral (Koné, Amadji, Touré, Togola, et al., 2013; Koné, Diatta, et al., 2009; Koné, Touré, Amadji, Yao-Kouamé, et al., 2013).

In light of current analysis, soil color use in field is a potential friendly method for soil fertility classification gathering indigenous and scientific methods as additional reliable tool for participatory land use planning in tropical environment.

4.2. Predictability of exchangeable soil K

The linear regressions observed for soil content of exchangeable K according to soil RR and RF, respectively, were exceptionally significant in the same manner characterizing the relation between soil-exchangeable K and water-soluble K in kaolinitic and mixed mineralogy soils Sharpley (1989). In fact, kaolinit is dominant in Ferralsol, but change in mineralogy can occurred throughout soil profile and along a toposequence (Diatta, 1996) though, still remaining 1:1 clay mineral (kaolinit and illit) in topsoil, while smectite can be observed in deep horizons and down slope. Consequently, the lack of fit observed for the linear models of K prediction in 80–150 cm soil depth of middle and foot slopes (Table 5) could account for such neoformations due to soil moisture and geochemistry (Azizi et al., 2011). However, soil content of K can be predicted by soil redness within 0–80 cm depth indifferently to the topographic positions. This result can be considered as a significant advance in methodology of soil survey, especially for annual crops. Actually, up to date, rapid assessment of soil content of K was only referring to laboratory data including complex method as near-infrared measurement (He and Song, 2006).

Furthermore, the current investigation may have implication in the prediction of soil Ca using the model of Pal (1998) for kaolinitic soil toward a readily estimation of soil cation exchangeable capacity (Bigorre, 1999; Larson & Pierce, 1994). Hence, the use of soil redness may increase the adoption of existing method of soil CEC estimation though; the prediction models (RR and RF) of Mg and Na are still required. Nevertheless, the current study may have significant contribution in pedometry, especially when using pedotransfert functions for estimation of soil cation saturation ratio, hence for easily evaluation of soil fertility in field.

The sensitivity of soil color to wetness (Poss et al., 1991) and the change of soil physic and chemical characteristics (Vizier, 1971) as observed for soil content of K (Koné, Diatta, et al., 2009), are further supporting current finding and relevant assertions.

However, there was scant evidence of correlation between soil RR and RF with soil content of exchangeable K, respectively, throughout soil profile as much as observed for Ca and Mg (Tables 3 and 4) asserting that Ca and Mg may be better predicted by soil redness indices than soil K. In fact, divalent cations are more relevant to soil redness (Koné, Diatta, et al., 2009; Segalen, 1969), while colloids dispersion induced by monovalent cations (Grolimund et al., 1998; Kaplan et al., 1996) may alter the red pigmentation. Well, beside of hematite, the red pigmentation of soil is also inducing by amorphous component (Mauricio & Ildeu, 2005; Segalen, 1969) accounting for soil colloidal phase.

In light of these analyses, there is also chance to predict soil contents of Ca and Mg using soil redness indices in away to estimate soil CEC *in situ* during agricultural soil survey. Of such investigation in future, agricultural land assessment may be strengthening, especially for Ferralsols.

5. Conclusion

Reddish topsoil of 2.5YR in color observed at hill slope positions (SUM and US) is identified as most enriched soil in K when referring to a cumulative frequency in high and medium K-levels. In turn, low soil K-level was accounting for deep soil horizon, FS position, and yellowish (7.5 and 10YR) soil while characterizing 50% of 5YR as soil color. Furthermore, it was revealed a predictability of soil K content within 0–80 cm depth using soil redness indices also advocated for *in situ* prediction of soil contents of Ca and Mg respectively toward the estimation of soil cation exchangeable capacity. Hence, further challenge was outlined concerning the prediction of soil contents of Ca and Mg using Munsell chart in Ferralsol environment. Overall, soil color was deemed as promising tool for improvement of soil fertility management.

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