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Ecosystem nutrient dynamics under short fallow systems in the humid forest zone of Southern Cameroon.

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Abstract.

Spontaneous fallow remains a crucial component for low input agricultural systems practiced through out the humid tropics. Despite this geoecological importance, less quantitative information is available on the effects of soil quality and fallow age on ecosystem nutrient dynamics, fertility recovery and system sustainability. We studied 100 short fallow sites across 5 soilscapes in the humid forest zone of southern Cameroon. The objectives were to capture the pattern of ecosystem nutrient build up and empirically evaluate ecosystem attribute interrelationships with respect to underlying biogeochemical processes. The soils in the region classified as Kandiudults and Kandiudox while fallow age ranged from 2 and 5 years. Principal component analysis (PCA) of the soil-fallow system indicated that nutrient uptake via biomass production, was the main source of variation accounting for 29.9% of total ecosystem nutrient variance (TENV). Organic carbon (OC) and nutrient accretion in the soil system emerged as the second source of variation with 16.7 % of TENV. Component 3 with 14.0 % of TENV highlighted the pedogenetic development gradient across the studied soilscapes and its effects effect organic matter mineralization. Component 4 and 5 reflected *Chromolaena odorata* density variation and its positive effect on available phosphorus (P) accumulation in soils, potassium (K) uptake in above ground biomass (ABG) and organic matter mineralization rate. The two-way analysis of variance indicated that soil P, OC, total nitrogen, and exchangeable K stocks varied significantly ($P<0.05$) across soilscapes. For those variables, neither the fallow age nor the interaction term was statistically significant. Available P stock was lowest (3.0 ± 0.4 kg ha^{-1}) in Rhodic Kandiudox derived from granodiorite and highest (7.4 ± 0.8 kg ha^{-1}) in Typic Kandiudox from charnockite. Calcium and Mg stocks varied across soilscape and fallow age but without a consistant trend. The two-way ANOVA confirmed the PCA results with above ground dry matter yield varying significantly between soilscapes ($P<0.001$) and fallow age ($P<0.001$). Mean AGB yield ranged from 13.4 ± 1.2 Mg ha^{-1} to 23.3 ± 2.7 Mg ha^{-1} with maximum values occurring during the 4th years. Interactive stepwise regression analysis revealed that labile phosphorus (P) was the main predictor of biomass production at 0.03 probability level. Maximum P stock in AGB occurred during the 4rd year. These results on ecosystem nutrient trend indicates that the

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practice of 4 years of fallow followed by one year of cultivation appears sustainable for the groundnut-based cropping system.

Key words: Ecosystem fertility; Southern Cameroon; *Chromolaena odorata*; fallow period;

Nutrient stock

1. **Introduction.**

Spontaneous fallow remains an essential component in low input agricultural systems through out the humid tropics (Kleinman et al., 1995; Burgers et al., 2005). In southern Cameroon, the fallow period has been significantly reduced with increasing population pressure exacerbated by the decline of the cocoa economy and the emergence of food crops as the main source of household revenue (Oyono et al., 2003). Groundnut (*Arachis hypogea)* mixed food system is one of the most important cropping system actually evolved into a semi-permanent systems (Büttner and Hauser, 2003; Gockowsky et al., 2004). Human-induced land degradation is estimated to affect about 40 % of agricultural land worldwide (Oldeman et al., 1990) with alarming nutrient depletion rates in highly populated areas mainly in subsaharan Africa (Smaling et al., 1996). This general trend constitutes a serious threat for rural agricultural production and people livelihoods mostly in the tropics (World Bank, 1997). Over the last 70 years, many attempts have been made in finding substitute technologies for enhancing soil fertility recovery in shifting cultivation systems through the planting of leguminous species. Among tested candidates, *Calliandra calothyrus* (Miessner) and *Puereria phaseoloides* have been reported to be well adapted to acid soil conditions. However, very limited successes have been achieved in terms of adoption for unknown biophysical and socio-economic reasons (De Jager et al., 1998; Alegre et al., 2005). Fallow length is an important factor for decision-making in resource management and field allocation to various agricultural land uses in indigenous communities. In southern Cameroon, if secondary forest or other successions of more than 15 years are used for plantain (*Musa paradisiaca*) or melon (*Cucumeropsis mannii*) fields, short fallows of less than 6 years are commonly targeted for the groundnut (*Arachis hypogea L.*) mixed food system (GMF) (Büttner and Hauser, 2003; Gockowsky et al., 2004). The GMF system commonly associates groundnut, maize (*Zea mays L.*) and cassava (*Manihot Esculenta Crantz*) with differential residence time in the field, nutrient availability as related to nutrient flush associated with burning and progressive soil deterioration. Groundnut and maize are high-nutrient demanding crops that take advantage of early better soil condition generated by biomass burning and nutrient released from the ash while cassava as the second main crop in terms of density reckoned to be efficient at exploiting scarce nutrient resources (Kotto-Same et al., 1997). Several studies carried out in the humid tropics (Kojo, 1994; Slaats, 1998) indicates that the use of short fallow resource even in condition of land abundance is a common practice. This observation rises concerns about the usefulness of longer fallows generally advocated by agricultural extentionists irrespective of the type of soils and cropping systems. The GMF system is highly important for household food security and is being practiced by more than 90 % of the farming community in southern Cameroon. There is a real need to investigate on system sustainability and empirically define an optimum fallow periods for better utilization of soil resource (Guillemin, 1956; Mertz, 2002).

Soils are essential components for the understanding of long-term agroecosystem productivity (Wolman, 1985; Kidd and Pimentel, 1992; Kleiman et al., 1995). Within a giving climatic zone, nutrient accumulation by secondary successions is a function of various mechanisms

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including internal cycling and deep uptake from subsoil horizons (Juo and Manu, 1996). One phytoecological issue in short fallow systems from slash and burn derived fields across the humid tropics of Central and West Africa (Cruttwel et Skarrat, 1996) and Asia (Kushwaha et al., 1981; Rhoder et al., 1995) is the prevalence of *Chromolaena odorata* (L.) R.M King and H. Robinson. As shown by Slaats et al. (1998) in southern Ivory Coast and Zapfack et al. (2000) in southern Cameroon, areas that have undergone several recurrent cycles of short fallow systems are characteristically monospecific with *Chromolaena odorata* accounting for more than 80 % of the fallow species population. With emerging knowledge-based systems (Zinck and Farshad 1995; Brand and Pfund, 1998), an empirical assessment of ecosystem nutrient build and biogeochemical processes is needed for system sustainability evaluation and land use improvement perspectives (Swift et al. 1994; Dhillion, 2000; Mertz, 2002). The objectives of this study were therefore twofold: i) to evaluate the spatio-temporal dynamics of ecosystem carbon and nutrient stocks under the GMF system as influenced by soil type and fallow duration and ii) capture the relative importance of driving processes active in ecosystem fertility recovery under short fallow systems in the humid forest zone of southern Cameroon.

2. Materials and methods

2.1. location and environmental setting

The study area is located in southern Cameroon between 11°25 and 12°50 E , 2°10 and 4°00 N (Fig. 1). The regional climate is subequatorial with mean annual rainfall ranging from 1500 to 1800 mm. The pattern is strongly influenced by orography, latitude and continentality. The high rainfall zone are located in hilly areas northwest and south of the studied zone. Depressional areas along the Nyong river with undulating relief

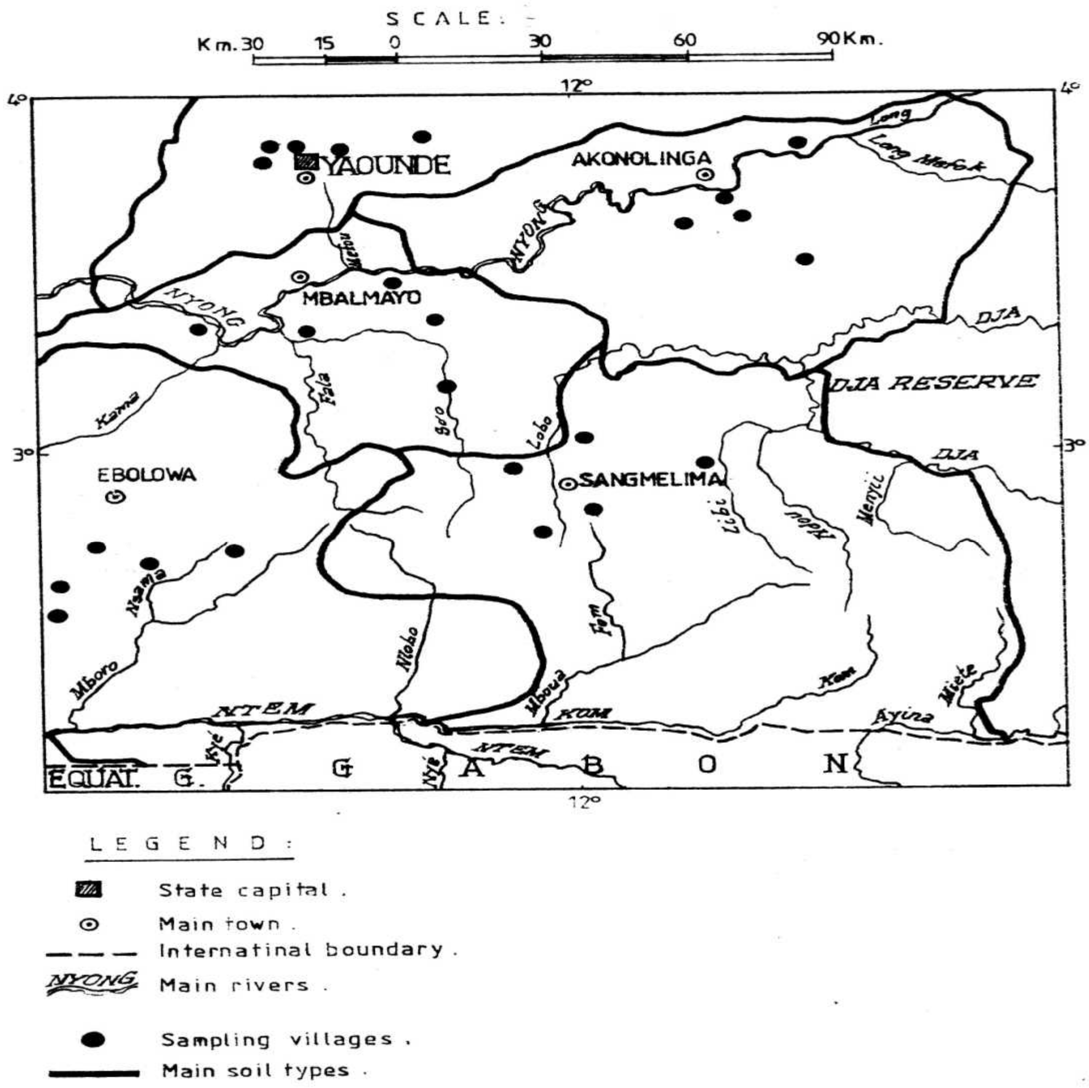

Fig.1. Location map showing sampling villages in southern Cameroon. The soilscapes are named after the soils and the main town where they dominantly occur. They are AKO (Akonolinga), MBA (Mbalmayo), SAN (Sangmelima), EBO (Ebolowa) and YAO (Yaounde). For they setting (see Table 1).

have the lowest mean rainfall The distribution pattern is bimodal with the first rainy season extending from mid March to July and the second from August to mid November. The temperature regime is isohyperthermic. The climacic vegetation is a semi-deciduous forest in the north passing gradually to the rainforest in the south. This climacic vegetation has been significantly disturbed by agricultural activities with cacao (*Theobroma cacao L.*), shifting cultivation systems and more importantly by forest exploitation. The population density decreases progressively southwards. Areas north Yaounde have a population a density around 72 persons/km^2 while southern areas towards the Gabon border have less than 6 persons/km^2.

2.2. Soils and vegetation sampling procedures

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Fieldwork was undertaken during the second rainy season in 2001 in 25 villages (Fig.1). Sampling villages was based on a macro-level soil characterization survey (Tchienkoua et al., 1990). The selected villages belonged to 5 soil landscapes in which dominant soils classified as Kandiudults and Kandiudox. (Table 1). On the basis of information provided by landowners, fallow-soil systems with similar slash and burn cultural histories (at least 4 recurrent cropping-fallow cycles) but differing in rest periods since the last cultivation phase were retained. Fallow age for the selected sites ranged between 2 and 5 years. Fields with long history of slash and burn were easily recognizable in the field by the absence of trees and dead trunks in the ground. In each of the 5 villages, 4 fallow sites of increasing age were surveyed giving a total number of 100 fallow sites across the 5 soilscapes.

Table 1
Summary information on the setting and classification of the soils in various soilscapes. Most soilscapes are consociations except for the soils derived from metasediments (schist and micashists)

Soilscape	Relief and Parent material	Soil type
Yaounde	Rolling hills on migmate and various gneisses	Rhodic Kandiudox Rhodic Kandiudult
Sangmelima	Undulating to rolling hills granodiorite	Rhodic Kandiudult Rhodic Kandiudox
Ebolowa	Rolling hills on charnockite	Typic Kandiudox Typic Kandiudult
Mbalmayo	Undulating low hills on Mbalmayo schist and So'o tonalite	Typic Kandiudult
Akonolinga	Undulating low hills on micaschist	Rhodic Kandiudult

In each fallow site, composite soil samples were systematically collected within a 2 m x 2 m quadrat. Soil sampling was done at standard depths of 0-5, 5-10, 10-25 and 25-50 cm using mini-profiles. Bulk density was measured in triplicate using 100 cm^3 cores. For vegetation, aboveground biomass was measured by cutting the whole biomass within the quadrat at ground level and weighing. The litter and the standing biomass components were measured separately. Prior to the destructive sampling, *Chromolaena odorata* abundance was quantified through a modified point "quadrat method" described by Daget and Poissonet (1971). In general, within the 2 m x 2 m quadrat, 4 orthogonally intersecting thin bands of 2 m long each were materialized. Species count were made along the bands and the percentage of *Chromolaena* plants obtained by dividing the number of occurrence of *Chromolaena odorata* on the total number of plants counted. Only living plants above 20 cm were considered.

2.3. Soil and vegetation analyses in the laboratory

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All soil analyses were carried out on air-dried samples ground to pass a 2-mm sieve. Particle-size analysis was determined by the hydrometer method (Gee and Bauder, 1986). Dry bulk density was measured from triplicate core samples collected in different horizons and dried at 105°C till a constant weight. Soil pH was measured potentiometrically in a 1:5 soil solution ratio. Organic carbon (OC) and total nitrogen (TN) were determined according to Walkley and Black (1936) and Bremner and Tabatabaï (1972) respectively. Basic cations comprising available calcium (Ca), magnesium (Mg), potassium (K) was measured following the Mehlich-3 extraction procedure and different elements determined by atomic absorption spectrophotometry (AAS). Available phosphorus (P) was measured by the Bray 1-P method. Vegetation samples were oven-dried at 65 °C till constant weight for moisture correction and subsamples of litter and biomass ground to pass a 0.5 mm mesh sieve. Plant samples were ashed at 450 °C and total P and N determined following *Novozamsky et al. (1983)*. Calcium, Mg and K in the extract were determined through using the AAS.

2.4. Data processing and statistical analyses

Soil organic carbon and nutrient stocks in the soil system were calculated till a depth of 25 cm. The calculation took into account soil layer thickness, bulk density and nutrient or organic carbon concentration provided by laboratory determinations. Nutrient stocks in AGB including litter was calculated by multiplying and summing up the recorded dry matter component yields by their respective concentrations. All the results were expressed per ha^{-1}. Weighted mean values for pH and clay content were also calculated for use in the multivariate analysis. For statistical analyses, each village was considered as a replicate. A two-way analysis of variance (ANOVA) using the general linear model was carried out to evaluate the effects of soilscape, fallow age and their interactions on soil and above ground nutrient stocks. The F-test was used to assess whether sample means were significantly different at the 0.05 probability level and means separated based on the Tukey´s HSD test. Principal component analysis (PCA) was used as an explorative statistical tool to unbiasedly summarize the ecosystem data set into few orthognized master variables called principal components (PC) and empirically model the relationships among driving variables controlling ecosystem fertility restoration. Data were standardized to zero mean and unit variance through the use of the correlation matrix. Principal component retention for interpretation purposes was based on the criteria of Eigen value more than 1 as suggested by Kaiser (Kaiser, 1960). Some redundancy was tolerated both for soil and vegetation systems to accommodate for their different interpretative significance. Stepwise regression analyses were also conducted to determine which soil plant nutrient stocks (Ca, Mg, K, TN, P) optimized or limited biomass production. All analysis was performed on SYSTAT statistical package (SYSTAT, 1993)

3. Results

3.1. Soil nutrient stock variation across soilscapes

The two-way ANOVA results showed that soil available P, organic C, Total N, and exchangeable K stocks differed significantly ($P<0.05$) across soilscapes. For those variables, neither fallow age nor the interaction term was significant. Following this result, data was pooled across soilscapes and submitted to a one-way ANOVA. The mean value for soil available P stock ranged from 3.0 ± 0.4 kg ha^{-1} in the SAN to 7.4 ± 0.8 kg ha^{-1} in EBO soilscape, the most acidic soils of the region (Fig. 2). The highest OC and TN stocks were observed in AKO and EBO soilscapes. Mean exchangeable soil K stocks ranged from 58.5 ± 4.1 to 87.8 ± 6.6 kg ha^{-1}. The highest values were observed in SAN and EBO soilscapes and the lowest values on AKO soilscape. Calcium and Mg stocks varied significantly across soilscape and fallow age (Fig. 3). Maximum Ca accumulation in the rhizosphere ranged from 703.5 ± 86.2 in AKO soilscape to 1225.0 ± 106.0 kg ha^{-1} on EBO soilscape. Maximum levels of Ca in soils were observed during the third year for EBO, YAO soilscapes, the 4th year for MBA and SAN and 5th year for AKO AKO. Maximum Mg accumulation in soils ranged from 168.1 ± 10.9 to 205.2 ± 36.8 kg ha^{-1} and follow a similar trend.

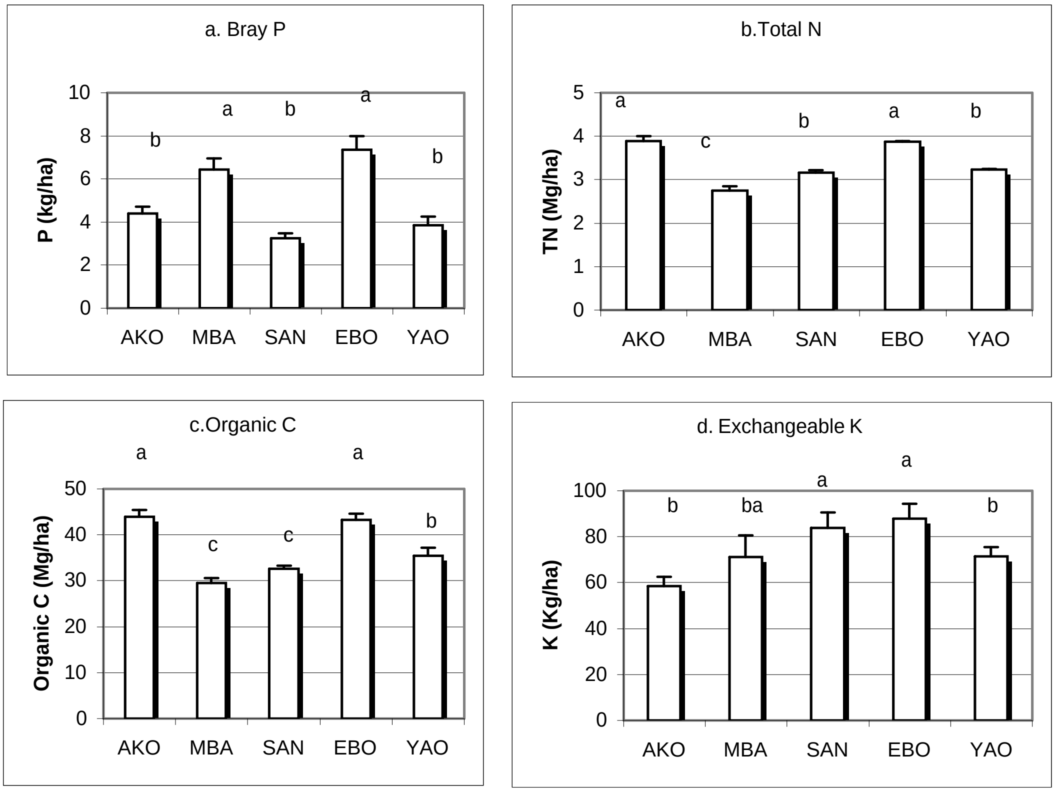

Fig.2. Mean and standard error of soil available P (Bray-P), total nitrogen (N), organic carbon and exchangeable potassium (K) stocks across soilscapes. The stocks are calculated for a depth range of 0 to 25 cm. AKO, MBA, SAN, EBO and YAO are soilscapes. For they setting (see Table 1). Values followed by different letters are significantly different at P <0.05.

3.2. Aboveground component

The two-way ANOVA showed a significant effect of soilscapes (P<0.001) and fallow age (P<0.05) on AGB yield and nutrients stocks. Above ground biomass yield ranged from 13.4 ±1.2 Mg ha^{-1} in AKO to 23.3 ± 2.7 Mg ha^{-1} in SAN soilscape (Fig. 4). The interaction term was however not significant. Maximum biomass buildup occurred generally during the 4th and 5th year. Total N co-varied with AGB ranging from 112.7 ± 31.6 to 290.5 ± 35.4 Kg ha^{-1}. Above ground P stock was 4.4 times higher than measured available P in the soil component. Phosphorus uptake peaked in the 4th year with greatest P accumulation being recorded in the SAN soilscape. The K stocks were very variable with maximum values ranging between 110.7 ± 13.7 kg ha^{-1} to 307.9 ± 42.3 kg

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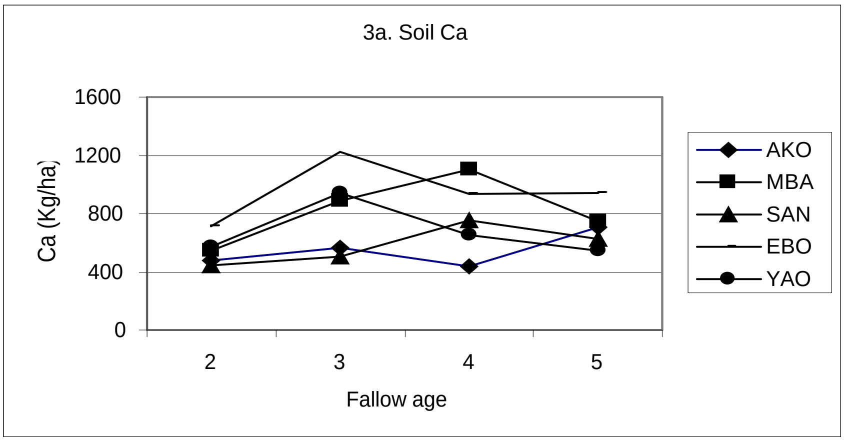

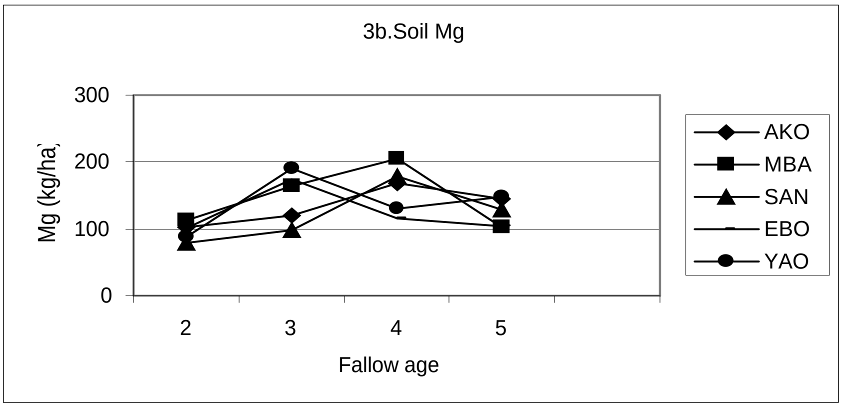

Fig.3. Soil Calcium (Ca) and Mg stock variation with soilscape and fallow age. Values are means from 25 sites. Fallow age are expressed in years. The stocks are calculated for a depth range of 0 to 25 cm. For the meaning of AKO, MBA, SAN, EBO and YAO are soilscapes (see Table 1).

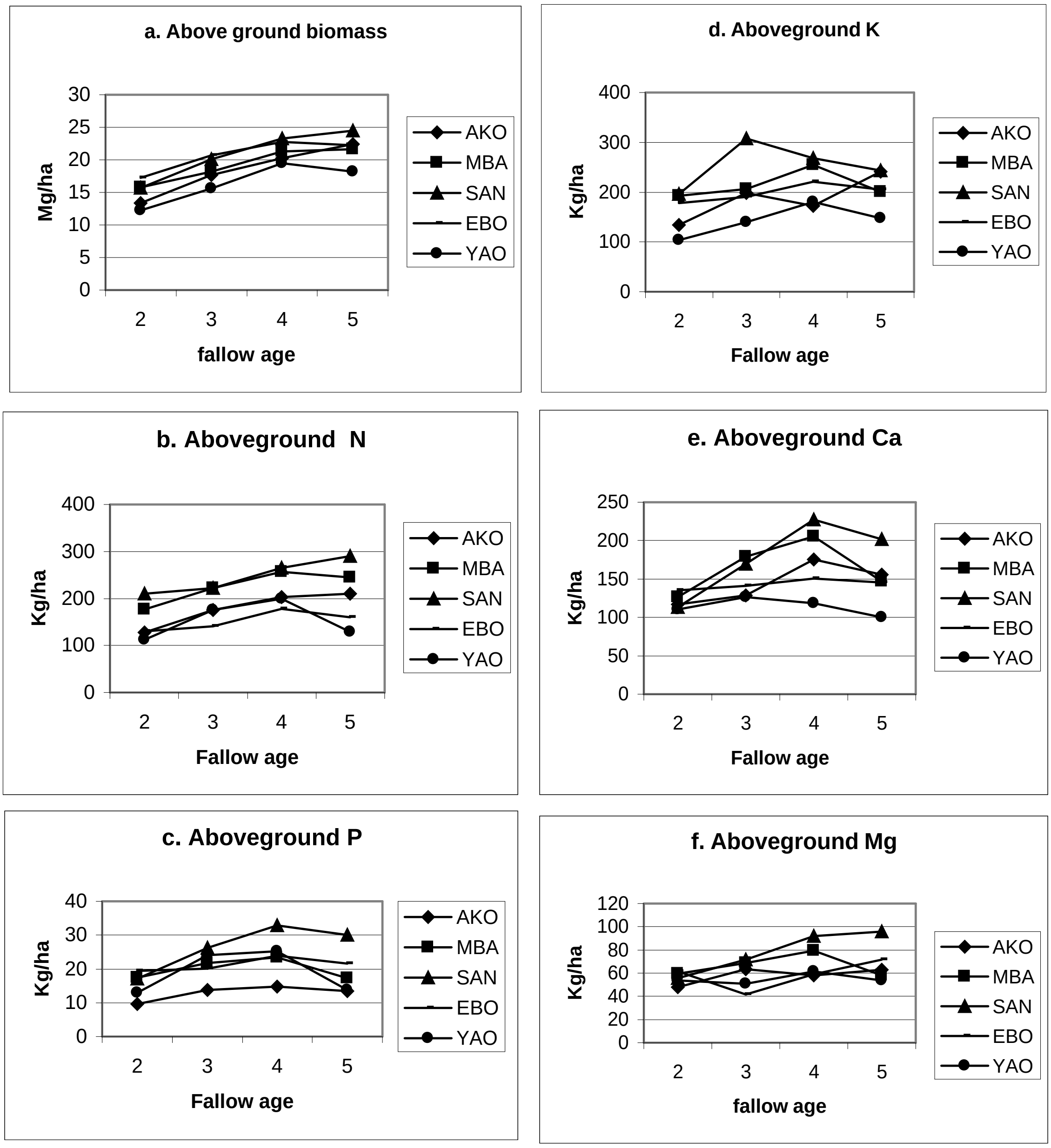

Fig. 4. Above ground biomass yield and nutrient stocks variation.

ha^{-1} between the 3rd and 5th year (Fig.4). Above ground calcium stocks increased was generally highest during the 4th year. The trend for Mg was similar peaking generally during the 4th year except for the EBO soilscape.

3.3. Principal component of the soil fallow interface

The soil-fallow interface exploration through PCA resulted in a 5 component-model, which explained 76.0 % of total ecosystem nutrient variance (TENV)(Table 2) The first component targeted primarily above-ground dry matter yield and Mg, Ca, available P stocks in above ground compartment, accounting for 29.9 % of TENV. Moderately loaded to PC1 variables include soil pH, available P and soil macronutrients (Ca, Mg). The second component had relatively higher loadings on TN, OC, soil macronutrients and moderate loadings on pH, soil K and available P. The first component exhibited a relatively higher loading on the fallow length variable compared to PC2. The third component was underlain by the soil clay fraction, followed by organic OC and TN (positively loaded) and all soil nutrient variables (negatively loaded). Of particular importance is the significant loading on above ground TN. Component 4 was dominated by *Chromolaena odorata* density, soil P on K stocks. Component 5 brought back *Chromolaena odorata* density in relation to OC and TN accumulation in soils. Interactive stepwise regression analysis with stocks of Ca, Mg, K, total N and Bray-P as dependent variables on total biomass yield indicated that Ca, Mg, K influenced positively biomass production but their effects were statistically not significant. Bray-P emerged as the best predictor of biomass yield at 0.03 probability level. When the data was analyzed per soilscapes, available P predicted AGB quite well in YAO and MBA landscapes ($P<0.05$) in contrary to SAN, EBO and AKO where the relationship was not significant.

Table 2.
Principal component analysis results of the soil-fallow system.

Soil variable	PC1	PC2	PC3	PC4	PC5
Chrom. Dens*	0.102	0.113	0.291	**0.569**	**-0.640**
Fallow length	0.252	0.187	0.075	0.128	0.037
Soil K	0.015	**0.423**	**-0.394**	**-0.528**	0.210
Soil Ca	**0.372**	**0.678**	**-0.404**	-0.064	0.044
Soil Mg	**0.389**	**0.687**	**-0.327**	-0.257	0.038
Bray-P	**0.320**	**0.415**	**-0.369**	**0.467**	-0.243
Total nitrogen	-0.120	**0.701**	**0.564**	0.179	**0.310**
Organic carbon	-0.171	**0.666**	**0.485**	0.376	**0.318**
PHwater	**0.350**	**0.471**	**-0.485**	-0.230	0.101
Clay	-0.219	0.086	**0.767**	-0.363	-0.029
AGB yield	**0.788**	-0.238	0.145	0.214	0.005
AGB P	**0.819**	0.044	0.077	0.023	0.292
AGB Ca	**0.868**	-0.193	0.077	0.023	0.292
AGB Mg	**0.869**	-0.242	0.105	0.070	0.243
AGB K	**0.818**	-0.029	0.209	-0.145	-0.116
ABGTN	**0.799**	-0.141	**0.317**	-0.003	-0.039
Eigen Value	4.79	2.67	2.27	1.60	1.17
Proportion (%)	29.9	16.7	14.0	8.6	6.8
Cumulative proportion	29.9	46.6	60.6	69.2	76.0

*ChromDens = *Chromoleana odorata* density. Soil variables included are mean values for the 0-25 cm soil depth. Boldface loadings are considered as highly weighted.

4. Discussion

4.1. Nutrient stocks and fluxes in short fallow systems

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The mechanisms and driving processes influencing the dynamics of mineral nutrients at the soil-fallow interface are complex (Szott et al., 1999; Serpantie and Ouattara, 2000). The high loadings on AGB yield and associated nutrient in PC1 stands obviously for fallow productivity and nutrient accumulation in aboveground vegetation (Duan et al., 2004). The process efficiency and overall system resilience is influenced by intrinsic soil properties such as soil pH and available nutrient (Mg, Ca and available P) considered as management-sensitive properties definitive of soil quality in shifting cultivation systems (Yemefack et al., 2005). The low loadings on soil nitrogen and potassium suggests that these nutrients may be relatively less critical in *Chromolaena odorata* spontaneous successions in these strongly weathered soils. The second component with 16.7 % of TENV reflects differential OC and plant nutrient accretion in soil system as a result of decomposition and mineralization processes (Sanginga et al., 1992; Swift et al., 1994). A similar component was identified by Paniagua et al.(1999) and labeled as the “soil protection and macronutrient availability” in regenerating degraded soils in Honduras. Biomass and nutrient build up process identified in PC1 together with carbon and nutrient accretion in soils (PC2) accounting for 46.7 % of ecosystem nutrient variability are interrelated processes expressive of the conceptual model of biogeochemical cycling and ecofertility build up in shifting cultivation systems described earlier by Nye and Greenland (1960). The relative higher loading (0.252) obtained on PC1 compared to PC2 (0.18) indicates that in short term aggrading systems greater variation in ecosystem nutrient variation generally occurs in the vegetation compartment (Pears, 1977). This finding accounts for the absence of significant changes in soil OC and nutrient in fallow systems reported by several authors (Rhoder et al., 1995; Kotto-same et al., 1997; Masse et al., 2004; Alegre et al., 2005). Component 3 with high loading on the clay fraction and moderate negative loading on soil reaction highlights differences in pedogenetic development across the studied soilscapes (Tchienkoua and Zech, 2004) and its incidence on soil biochemical processes. In the more acidic soils, ammonification are enhanced leading to increasing accumulation of NH_4^+-N and a reduction in nitrate leaching (Alegre et al., 2005; Kemmitt et al., 2005). The 4th and 5th components evidence fallow floristic differences in terms of *Chromolaena odorata* density and its importance in P mobilization in soil and K accumulation in above ground biomass. In the context of the present study, *Chromolaena odorata* density ranged from 71.7 ± 7.5 % to 87.5 ± 1.7% with *Triumfetta cordifolia* and S*tachytarpheta cayensis* as the most important associated weed species.

4.2. Ecosystem nutrient dynamics and optimum fallow period

The range in fallow dry biomass production are relatively close to those published by Brand and Pfund (1998) in the humid area of Madagascar who found values of 14.2 ± 5.5 Mg and 23.7± 16.6 for AGB yield in 3 and 5 years of fallow respectively. Toru Hashimoto et al. (2000) reported a range of 12.1 to 22.5 t/ha in a 3-5 years secondary forest regrowth of Borneo even though their secondary succession was floristically dominated by *Imperata cylindrica*. The aboveground compartment with 69.3 % of ecosystem K on an average basis revealed the major pool for K compared to available soil K pool. The soil component stored also more available Ca and Mg (about 5 and 2.2 times respectively) compared to AGB compartment. Similarly more than 90 % of ecosystem N was found in the rhizosphere. The functional relationship between *Chromoleana odorata* density and P and K stocks in surface soil horizons and AGB compartment highlights the benefit associated *Chromolaena odorata* in terms of ecosystem nutrient improvement. This finding corroborates with previous work in the same area (Tchienkoua and Zech, 2002). Soil OC, TN, P and K nutrient pools showed no relation with fallow age. Similar results have been reported for soil Ca, Mg ad K by Dhillion (2000) in Indonesia, Masse et al., (2004) in humid southern Senegal and Alegre et al. (2005)

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in Peru. The highest ecosystem K observed in the EBO and SAN soilscapes reflects the higher K availability in the charnockite parent material (Tchameni et al., 2000) but also soil high clay content. Soil labile P pool emerged as the nutrient most correlated with biomass production emphasizing on the importance of P as the most limiting nutrient in strongly weathered soils (Walker and Syers, 1976; Vitousek and Sanford; 1986). The non significance of the relationships between soil Bray P and above ground P pools in the SAN and EBO soilscapes probably points at the utilization of less labile pools by *Chromoleana odorata* via micchorizal-root association and other P mobilizing mechanisms (Tiessen et al., 1992). Darrell et al.(2003) hypothesized that P limitation may shift towards N following repeated cycles of slash and burn and cumulative losses of N through volatilization. In this study N revealed being of secondary importance in *Chromoleana* regrowth probably in relation to acidied soil conditions that reduces nitrification in favour of NH_4^+-N less susceptible to leaching (Alegre et al., 2005; Kemmitt et al., 2005). In shifting cultivation, ecosystem nutrient stocks is the primary resource on which farmers capitalize for the success of their subsequent crops. Within each soilscape, ecosystem nutrient variation was more associated with the above ground component which revealed to be the main determinant of optimum fallow periods. In all soilscapes, the highest AGB yield occurred during the 4th and 5th years probably in relation to *Chromolaena odorata* phenology (Kushwaha et al.,1981; Cruttwell and Skarratt, 1996) with soil phosphorus being the most important limiting nutrient . The temporal AGB production trends indicate that the highest above ground P occurred during the 4th year irrespective of soilscapes. Considering sustainability as the fitness of land to maintain its food productive capacity for the subsistence requirement of people (Komatsu et al., 2005) and based on the simple model of crop-fallow system (55 % of maximum soil fertility) as suggested by Van Noordwijk (1999), we might conclude that 4 years of fallow followed by one year of cultivation for GMF is sustainable. This result in in line with those of Büttner and Hauser (2003) for southern Cameroon, Kojo (1994) for Ghanaian soils and Slaats (1998) in southern Ivory Coast**.** However long term improved fallow management strategies need to be developed. There is no doubt that planting leguminous trees enhances N availability and fallow productivity (Alegre et al., 2005) but P as the most limiting element is soil-borne and need to be supplied for yield optimization.

4. Conclusions

This study provides baseline information on ecosystem nutrient dynamics in short fallow systems used by poor resource-farmers for GMF systems in southern Cameroon. Multivariate analysis indicated that fallow productivity and overall system resilience was more dependant on above ground component modulated by edaphic conditions. Maximum dry matter production, P and other nutrient accumulation in fallow vegetation occurred generally during 4 years of fallow, supporting the practice of short fallow systems by the majority of farmers even in condition of land abundance (Büttner and Hauser, 2003). Despite the empirical adaptation of the GMF system to actual fallow attributes, sustainability should be judged not only by the food productive function but also by the agroecosystem efficiency in recycling nutrients. Phosphorus availability appears as the primary constraint for system intensification and yield optimization. An in-depth assessment of soil P status in terms of P capital and partitioning into conceptual bioavailable pools and mechanisms of P acquisition is essential. Taking into account farmer socio-economic conditions, and the acidic nature of the soil resource base, cheap source of P such as rock phosphate with longer residence time in soils and the testing of several lines of promiscuous legumes for their performance in P acquisition are sound research pathways that needs to be explored for land use intensification in acid soils of the humid tropics.

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