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Research Paper

Effect of Continuous Intensive Cultivation on the Chemical and Microbiological Properties of Oxic Dystrandept Soils in the Western Highlands of Cameroon

NTANGMO TSAFACK Honorine[1]* • YEMEFACK Martin[2] • TEMGOUA Emile[3] • AZINWI TAMFUH Primus[3] • NJOMGANG Rosaline[4] • TCHUMTCHOU Armel Landry[5] • NJINE Thomas[5]

[1]Research Unit of Applied Biology and Ecology, Department of Animal Biology, Faculty of Sciences, University of Dschang, PO Box 67 Dschang, Cameroon P.O. Box 365 Dschang, Cameroon.
[2]International Institute of Tropical Agriculture (IITA-Cameroon), P.O. Box 2018 Yaoundé, Cameroon.
[3]Research Unit of Soil Analysis and Environment Chemistry, Department of Soil Sciences, Faculty of Agronomy and Agricultural Sciences, University of Dschang, PO Box 222 Dschang, Cameroon.
[4]Laboratory of the Soil, Plants, Manure and Water, Institute of Agronomic Research for Development, Institute of Agricultural Research for Development, PO box 2123, Yaoundé, Cameroon.
[5]Laboratory of General Biology, Department of Animal Biology and Physiology, Faculty of Sciences, University of Yaoundé I, PO Box 812 Yaoundé, Cameroon.

Corresponding author: Email: tsafackhonorine@yahoo.fr

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Abstract. Soil fertility indices are well documented as they are directly related to land use and productivity. However, the effect of continuous intensive cultivation on the evolution of soil fertility is still poorly documented. The aim of this study was thus to assess the effect of continuous intensive cultivation on the chemical and microbiological properties of Oxic Dystrandept soils in the Western Highlands of Cameroon. Composite soil samples were taken between 0-15 cm depths on farmlands that have been subjected to continuous intensive cultivation for one, five and ten years meanwhile samples from plots that have never been cultivated served as control. The main results revealed that the ammonium contents dropped abruptly (86%-wt) from the first year of cultivation. The organic carbon (OC) content decreased from 1.81 ± 0.14 %-dm (in control) to 1.69 ± 0.09 % after one year, 1.66 ± 0.10 % after 5 years and 1.58 ± 0.07 % after 10 years. Compared to the control, available phosphorus (P) showed a 13 %-wt drop after one year, 46 % after 5 years and 85 % after 10 years. Dehydrogenase activity showed a 42 % decrease after one year, 50 % after five years and 73 % after 10 years. The other parameters were not significantly different (P<0.05) amongst treatments. Decline of soil productivity was undoubtedly related to the decrease of OC, P, microbial activity and ammonium with continuous intensive cultivation. Thus, management strategies for improved crop production should include selection suitable cropping systems and chemical methods. Thus, management strategies for improved crop production should include selection suitable cropping systems and chemical methods.

Keywords: Continuous intensive cultivation, enzymatic activities, soil chemical properties, oxic dystrandept, Cameroon western highland.

INTRODUCTION

Agriculture remains one of the most important economic sectors in Cameroon contributing more than 30% of the raw internal product and occupying more than 60 % of the active population (MINADER, 2005). Until the mid-

1980s, coffee was the principal source of revenue for farmers in Fongo-Tongo in the Menoua Division of West Cameroon. The disengagement of the state from this sector coupled with a drastic increase in prices of farm inputs and the fall of coffee prices in the world market has discouraged many coffee farmers who have then resorted to food crop cultivation. Crop production is done in an intensive and continuous manner. Nevertheless these crops are exigent and very sensitive to diseases and pests; quickly deplete soil fertility and thus requiring much pesticides and fertilizers to maintain high yields. This pressure on land has numerous detrimental consequences on soil quality considering that despite the numerous efforts to restore productivity (use of pesticides and fertilizers), the farmers in Fongo-Tongo have continued to complain of decline productivity as the years pass. Cordedo and Ramiry (1976) have noted a decline in soil fertility in Costa Rica due to excessive application of copper-based fungicides in banana plantations to the extent that the soils become completely barren at some areas of the plantation. Also in Iraq, the excessive and continuous use of natural and chemical fertilisers induced a high salinity of the soils making some soils unproductive (Halas, 1965). At short term (not more than 90 days), fertilizer application on an individual basis has led to the decline of available phosphorus and exchangeable ammonium as well as the activities of dehydrogense and β glucosidase (Carbonell *et al.,* 2000; Monkiegje and Spiteller 2002; Demanou, 2005; Monkiedje *et al*., 2007).

The basic mechanisms affecting soil quality do not only result from the action of soil organisms (earthworms, ants, termites etc) but also from that of microflora (bacteria and fungi) through the production of enzymes. Enzymes in soils have a range of activities in the different aspects of soil organic matter metabolism (Bachelier, 1973; Alexander, 1977; Thionbiano and Dianou, 1999; Zombre prosper 2006). Enzymes hydrolyse complex compounds, liberate nutrients and mineral elements (N, P, S, C, …) which can then be easily absorbed and assimilated by plants and other soil organisms. The continuous and long term use of nitrogen and phosphorus fertilisers alongside chemical pesticides can lead to a reduction of this activity (arysulfatase, cellulase, dehydrogenase, protease, urease, glucosidase, invertase), a significant drop in pH (Cleyet and Hinsinger, 2001; Kunito *et al*. 2001; Pernes-Debuyser and Tessier, 2002; Demanou, 2005; Monkiedje *et al.*, 2007) and hence a drop in soil fertility.

The clearing of woodland for low input arable cropping often leads to a decline in soil organic matter or soil organic carbon (SOC) and soil nutrient levels, as has been shown in pan-tropical reviews (Kleinman *et al*., 1995; Ribeiro Filho *et al*., 2015). The negative impacts on SOC levels were confirmed by the few published studies from semi-arid regions in sub-Saharan Africa (Walker & Desanker, 2004; De Demessie *et al.*, 2013; Touré *et al*., 2013; Luther-Mosebach 2017; Blécourt *et al.*, 2018). Perhaps, there is no available published work for this region on the impacts of this land-use conversion on soil nutrient levels. Most detailed investigations on the modification of soil properties through the application of pesticides and fertilizers were generally focussed on short term effects (Monkiedje *et al.*, 2002; Defo, 2003; Demanou, 2005). Yet, in rudimentary farming as the case of the present investigation, the results of a field survey did not reveal a particular plot of land where only one pesticide or fertiliser are being used. Generally, farmers associate all sorts of pesticides and fertilizers in various rounds per annum and for so many years. What can be the effect of this practice on the soil fertility parameters? The aim of this work was therefore to assess effects of continuous intensive farming on soil chemical and microbiological properties in order to understand the causes of soil fertility and drop of productivity crop farm in Fongo-Tongo as the years pass. The results obtained will serve as a baseline to farmers on land management strategies to improve productivity continuous intensive cultivation of land.

MATERIALS AND METHODS

Study area

Fongo-Tongo village group is located in the Fongo-Tongo Sub-division in the Menoua Division (West Region of Cameroon). The climate is the sub-tropical mountain type (Ngoufo, 1988), fresh and humid and marked by a long rainy season (Match to November) and a short dry season (December to February). Mean annual rainfall is 1700 mm and the mean annual temperature is 18°C. The relief is undulating, gentler in the upper zones and steeper in the lower lands. The natural vegetation is tree savannah which has been strongly degraded, with relics of raphia bushes in the lowlands. The drainage pattern is sub-dendritic. The main geological formation is trachyte overlying a granite-gneiss Precambrian basement. The soils are Oxic dystrandept or andic ferrallitic soils (Leumbe Leumbe *et al.*, 2005). Four villages at the North of Fongo-Tongo village group with similar geographic, climatic and farming characteristics were selected for the present study including: Tchouteng, Lensap, Lembet and Melang (Figure 1). The geographic coordinates are latitudes 5°34′ - 5°36′ Nord, longitudes 10°01′ - 10°03′ Est and altitude of 1800 - 1900 m (IGN, 1974).

Farming techniques in the studied sites

The results from the field survey revealed that the cultivated fields have often been subjected to annual crop rotation. Irrigation is practised in the dry seasons. Tilling is either flat or in beds using a hoe which hardly goes beyond 15 cm depth. The most practised speculations are Irish potatoes, maize, cabbage, licks, sweet pepper,

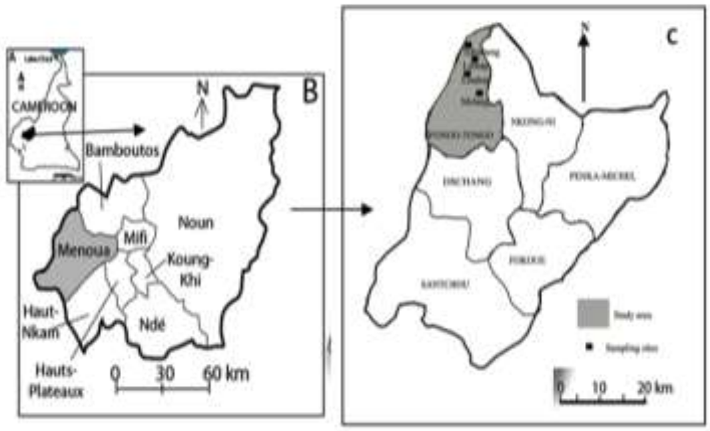

Figure 1. Location of the studied area within Cameroon (A), in the Western Region (B) and in the Menoua Division (C). Abridge title: Presentation of the study zone

beans, celeries, Tomato and Carrot. A wide range of insecticides, fungicides, herbicides, chemical and natural fertilizers are used. Phyto-sanitary treatment begins after plant germination and ends three weeks before harvesting for Irish potatoes and lately for the other crops. The application of insecticides and fungicides is done two to four times per month. All powder or granular pesticides are dosed with the help of old storage cans, between 0.33 and 0.45 g m^{-3} and liquid pesticides between 0.45 and 0.70 ml m^{-2}. The mean fertilizer application is 500 kg ha^{-1} for poultry manure. The pesticide and fertilizer doses have remained the same for more than a decade.

Experimental description and sampling

The study started with a survey including 120 randomly selected farmers in the four selected villages: 13 farmers in Tchouteng, 22 in Lensap, 39 in Melang and 46 in Lembet. The results obtained on farming techniques served as a useful guide towards farmland selection for sample collection.

The soil samples were collected along a chronosequence, comprised of:

10 plots that have never been cultivated (control) under natural savannah located on the same soil units as the cultivated plots;

10 plots that have received almost the same treatments (type and frequency of cultivation, application dose and frequency of inputs such as insecticides, fungicides, herbicides and NPK 20-10-10 fertilizers and fowl manure) for one, five and 10 years of exploitation.

All the selected plots were located on gentle slopes (2-5 %) and under natural savannah before onset of cultivation according to the results of the survey. The size of each selected plot was 100 m by 50 m. Each plot was sub-divided into five experimental units of 50 m by 20 m. Five soil samples were taken at the surface horizon (0-15 cm depth) along each of the five experimental units within a plot and the 25 samples were mixed to constitute a composite sample per plot, making a total number of 10 composite samples per treatment and a total of 40 samples for the four land use systems based on duration of intensive cultivation.

In the laboratory, the enzyme activity (dehydrogenase and phosphatase acid activities) and the soil chemical properties (organic carbon, available phosphorus exchangeable ammonium pH and electrical conductivity) were used to evaluate the effect of continuous intensive cultivation on soil quality. The pH (H_20) and electrical conductivity were measured in a soil/water suspension of 1:2.5 using a pH meter and a conductimeter respectively. Organic carbon was determined by Walkley and Black method (Walkley and Black, 1934), total nitrogen according to Kjeldhal method (Kjeldhal, 1988) and available phosphorus by Bray2 method (Bray 2, 1988). Exchangeable ammonium in fresh soil was extracted with a 2M KCl solution and dosed by colorimetry (Tan 1996; Anonymous 2000). Dehydrogenase activity in fresh soil was extracted by methanol and TPF (Triphenyl formazan) resulting from the reduction TTC (Triphenyl tetrazolium chloride) in the soil was dosed by colorimetry (Casida *et al.,* 1964). The activity of phosphatase acid in fresh soil was measured by quantification of the p-nitrophenol liberated by the reaction on p-nitrophenyl-phosphate at pH 6.5.

Statistical analysis

The data obtained were analysed using elementary descriptive statistics. The treatment effect was evaluated by simple ANOVA at $P<0.05$. The separation of means was done by Tukey's method using SYSTAT software

Table 1. Quality of data (n = 34) EC: electrical conductivity; OC: organic carbon; TN: total nitrogen; AP: available phosphorus; E am: exchangeable ammonium; Ph acid: phosphatase acide; dehy: dehydrogenase

Soil properties / Statistical parameters	pH(H_20)	EC (µS/cm)	OC (%-dm)	TN	AP ($mg.kg^{-1}$)	Eam ($mg.kg^{-1}$)	Ph acid (g PNP/g soil /h)	Dehy (g TPF/g soil/24h)	Clay (%-wt)	silt (%-wt)	sand (%-wt)
Minimum	5.1	25	1.38	0.09	0.3	0.00	231	82	37.27	24.09	5.49
Maximum	6.18	357.0	2.03	0.17	16.49	9.12	1796	1236	48.67	54.37	33.82
Mean	5.5	191	1.66	0.18	7.1	1.21	752	461	43.75	41.41	14.88
Median	5.5	199	1.65	9.12	6.8	0.00	659	407	43.16	40.74	14.43
Standard deviation	0.3	91	0.13	0.04	4.8	2.3	328	265	3.04	5.41	5.76
Standard error	0.05	16	0.02	0.01	0.82	0.4	56	45	0.82	0.92	0.98
Coefficient of Asymmetry	0.06	-0.21	0.50	-0.35	0.24	2.29	1.36	0.81	0.01	-0.26	0.85
Coefficient of flattening	-0.88	-0.81	1.30	-1.04	-1.07	4.37	1.87	0.42	-0.97	2.26	1.56
Coefficient of variation (%)	53	48	8	31	68	190	0.44	57	0.07	0.13	0.38

Table 2. Probability of variability of the all site' soil parameters (n=10 per treatment).
EC: electrical conductivity; OC: organic carbon; TN: total nitrogen; AP: available phosphorus; E am: exchangeable ammonium; Ph acid: phosphatase acide; dehy: dehydrogenase

Soil properties / Probability of treatments (0 à 1)	Control	One year	Five years	10 Years
pH(H_2O)	0.707	0.308	0.455	0.824
EC	0.723	0.970	0.480	0.609
OC	0.469	0.551	0.970	0.834
AP	0.812	0.617	0.635	0.931
Eam	0.878	0.304	0.459	NA
TN	0.322	0.584	0.146	0.099
Dehy	0.062	0.255	0.335	0.075
Ph acid	0.292	0.641	0.809	0.771

(SYSTAT 1993).

RESULTS

Data quality

The data distribution was very close to normality except for exchangeable ammonium and phosphatase acid (Table 1). Nevertheless, data transformation was not necessary because ANOVA is not sensitive to slight variations in normality according to Webster (2000). Generally, apart from exchangeable ammonium, phosphatase acid and silt, the rest of the studied soil properties showed a nearly normal distribution, with flattening and asymmetric coefficients close to zero. The data were characterized by high dispersion as portrayed by the relatively high standard deviations and coefficients of variation (CV %), especially for exchangeable ammonium, available phosphorus, dehydrogenase activity and pH (H_2O) with CV>50 %.

Homogeneity of the results

Within each of the treatments (duration of cultivation), there was no significant difference (P<0.05) amongst the variables (Table 2). This implies that the samples collected from each site were comparable for each treatment. Thus, all data within each site was used as repetition for all the treatments.

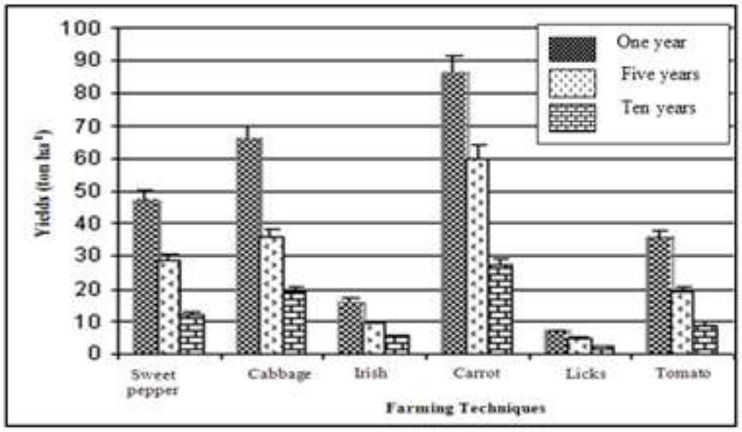

Figure 2. Evolution of yields ± standard deviation of the principal crops in Fongo-Tongo from a survey of 120 farmers. Abridge title: Evolution of crops production

Evolution of yields in Fongo-Tongo

The evolution of yields of some crops in Fongo-Tongo on the same plot was obtained from field survey reports from the Menoua Divisional Delegation of Agriculture and Rural Development (Figure 2). In fact, the farmers of Fongo-Tongo estimate their yields in number of bags, bundles, baskets or net yield per hectare. The yields per hectare are highest for the first year. After five years of continuous intensive cultivation, the yields drop for all the crops. There is an alarming yield drop of 60-70 % after 10 years of continuous cultivation (Figure. 2).

The evolution of the soil properties with cultivation time is presented in Figure 3. The pH (Figure. 3A), activity of phosphatase acid (Figure. 3H) and total nitrogen (Figure. 3D) were not significantly (P<0.05) affected by the duration of intensive cultivation. However, there was a slight drop after the first year of cultivation. The electrical conductivity (Figure. 3B), organic carbon (Figure. 3C), available phosphorus (Figure. 3E), exchangeable ammonium (Figure. 3F) and dehydrogenase activity (Figure. 3G) were significantly (P<0.05) affected by the duration of intensive cultivation. After the first year of intensive cultivation, there was a strong increase in electrical conductivity before a gradual drop was observed with time. The OC contents dropped from 1.81 %-dm in the control to 1.58 % after 10 years of cultivation. This decline was gradual from 6.63 %-dm after one year, 8.84 % after 5 years and 12.70 % after 10 years. The drop in available phosphorus was first gradual, then sudden after five years; it dropped from 12.3 ± 1.8 ppm to 1.9 ± 1.2 ppm between zero and 10 years of cultivation. The decrease was 13 %-wt after one year, 46 % after five years and 85 % after 10 years. The exchangeable ammonium dropped drastically (86 %) after the first year, then continued gradually and completely depleted after 10 years, passing from 6.8±2.4 ppm in the control soil to 0 ppm after 10 years. The sharp drop of dehydrogenase activity passed from 896 ± 253 µg TPF/g soil/24h to 238 ± 145.1 µg TPF/g soil/24h after 10 years of cultivation. This corresponded to a 42% drop from the first year, 50 % after five years and 73 % after 10 years. On the contrary, the activity of phosphatase acid was not significantly (P<0.05) affected by the duration of intensive cultivation. Nevertheless, there was a noticeable gradual drop with the duration of cultivation, passing from 1024 ± 447.1µg PNP/g sol/hr in the control to 688 ± 350.9 µg PNP/g sol/h after 10 years.

Correlation between the soil characteristics

The correlation coefficients among the different soil characteristics are presented in Table 3. Before onset of cultivation, a significant positive correlation was observed between OC, available P, exchangeable ammonium, dehydrogenase, phosphatase acid and C/N ratio. The pH (H_2O) was positively correlated with OC, available P, exchangeable ammonium, phosphatase acid and C/N ratio. The EC was negatively correlated with all the other properties except C/N ratio. At the end of the first, the fifth and tenth year of cultivation, only few characteristics were significantly correlated. Apart from exchangeable ammonium of the control which is positively correlated with C/N ratio, all the other treatments show that C/N was strongly correlated with exchangeable ammonium and phosphatase acid.

DISCUSSION

The findings in the present study revealing reduced SOC concentrations (Figure. 3E) in agriculture land following the conversion from woodland

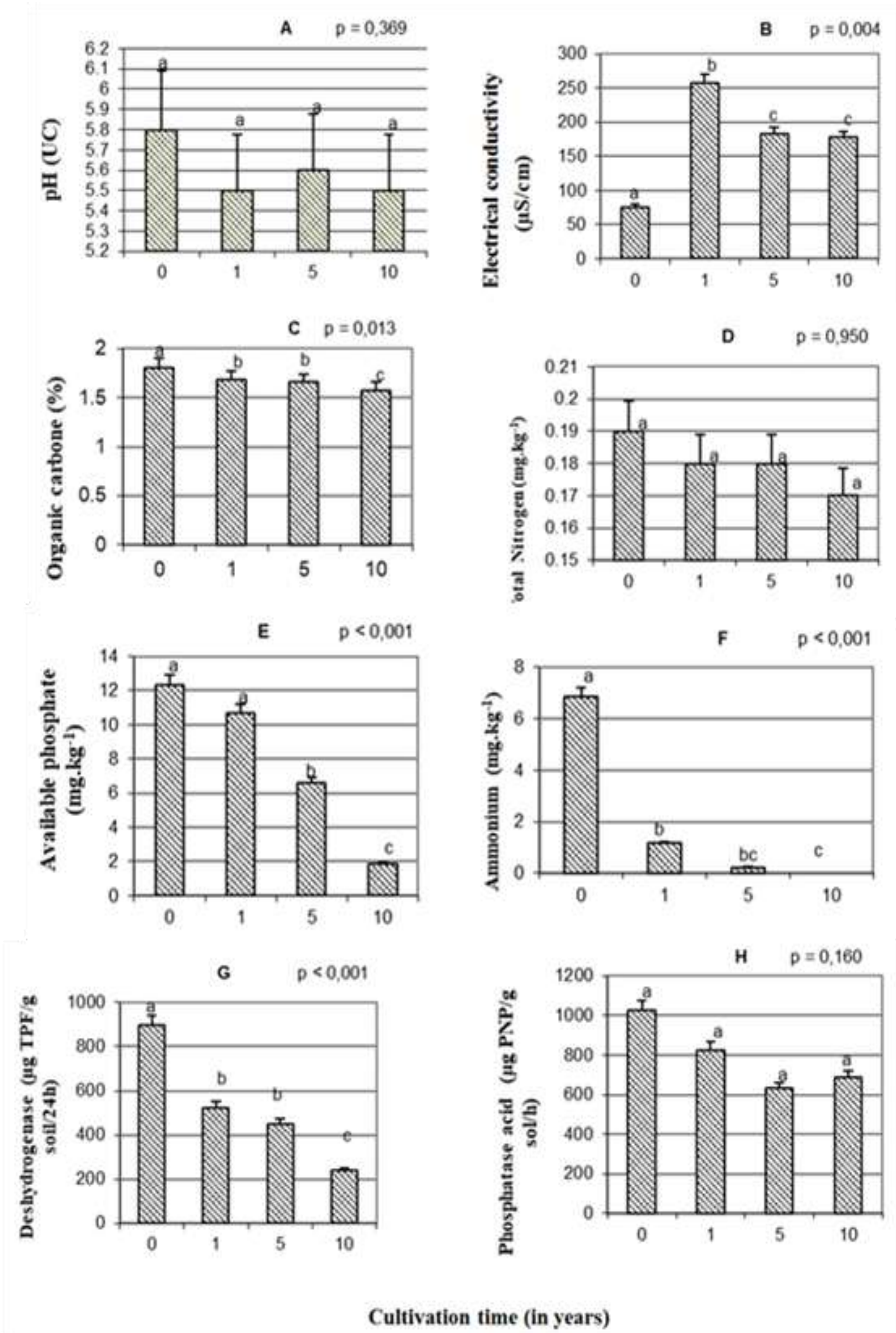

Figure 3. Evolution of chemical and microbiological properties of the soil with time of continuous intensive cultivation. The vertical bars represent standard deviation; Vertical bars followed by different letters imply that they are significant different (P<0.05). Abridge title: Evolution of soil properties with time

are commonly documented (Ribeiro Filho *et al.*, 2015; Walker and Desanker, 2004). De Blécourt *et al*., (2018) observed that total SOC stock losses (100 cm depth) in the Namibian study area, which ranged from 38.6% to 1.9% with an average loss of 19.6% (±18.4 SD). These correspond well with the losses reported by the few other

Table 3. Correlation coefficients between the different soil properties for the different treatments *(n=10)*
EC: electrical conductivity; OC: organic carbon; TN: total nitrogen; AP: available phosphorus; E am: exchangeable ammonium; Ph acid: phosphatase acide; dehy: dehydrogenase

Soil properties	pH(H_2O)	E. Cond	OC	T N	av P	Am	Ac Dehy	Ac Phos ac	C/N ratio
				Zero years					
pH(H_2O)	1								
E. Cond	-0.54**	1							
OC	0.72**	-0.74**	1						
T N	-0.38*	-0.56**	0.00	1					
av P	0.65**	-0.50**	0.95**	-0.22	1				
Am	0.89**	-0.12	0.38*	-0.69**	0.39*	1			
Dehy	0.11	-0.05	-0.47**	0.13	-0.66**	0.27	1		
Phos ac	0.98**	-0.53**	0.59**	-0.33*	0.49	0.90**	0.32*	1.00	
C/N ratio	0.66**	0.14	0.49**	-0.87**	0.67**	0.76**	-0.39*	0.54**	1.00
				One year					
pH(H_2O)	1.00								
E. Cond	0.10	1.00							
OC	0.44*	0.22	1.00						
T N	0.21	0.29	-0.07	1.00					
av P	0.21	-0.18	0.23	0.41*	1.00				
Am	-0.46**	0.25	-0.05	0.06	-0.55**	1.00			
Ac Dehy	0.01	0.20	0.35*	-0.28	0.03	-0.44*	1.00		
Ac Phos ac	0.55**	0.47**	0.28	-0.03	-0.33*	0.17	-0.26	1.00	
C/N ratio	-0.06	-0.17	0.15	-0.95**	-0.40*	-0.03	0.14	0.20	1.00
				Five years					
pH(H_2O)	1.00								
E. Cond	-0.26	1.00							
OC	0.13	-0.07	1.00						
T N	0.28	0.45**	0.04	1.00					
av P	0.12	0.17	-0.26	0.74**	1.00				
Am	0.39	-0.07	0.35*	0.25	-0.03	1.00			
Ac Dehy	-0.25	0.02	0.09	-0.20	-0.13	-0.39*	1.00		
Ac Phos ac	-0.39*	-0.28	0.16	-0.66**	-0.53**	-0.49*	0.10	1.00	
C/N ratio	-0.33*	-0.44*	0.15	-0.96**	-0.65**	-0.16	0.24	0.62**	1.00
				Ten years					
pH(H_2O)	1.00								
E. Cond	-0.81**	1.00							
OC	0.37*	-0.30*	1.00						
T N	-0.04	0.38**	-0.28	1.00					
av P	-0.09	0.02	0.38*	-0.19	1.00				
Am	-0.04	0.38*	-0.28	1.00	-0.19	1.00			
Ac Dehy	-0.20	-0.26	0.07	-0.58**	-0.21	-0.58**	1.00		
Ac Phos ac	-0.09	0.02	0.38*	-0.19	1.00	-0.19	-0.21	1.00	
C/N ratio	0.11	-0.39*	0.47**	-0.97**	0.28	-0.97**	0.55**	0.28	1.00

**Significant at the P<0.01 probability level; *Significant at the P<0.05 probabiliy level

studies on the conversion to low input agriculture in the semi-arid ecosystems of sub-Saharan Africa (Demessie *et al.*, 2013; Luther-Mosebach, 2017; Touré *et al.*, 2013; Walker and Desanker, 2004). A chronosequential study on an Andic Paleustalfs in southern Ethiopia showed that the conversion from forest to agriculture and agroforestry reduced SOC stocks by 12% to 43% after 12 to 50 years of cultivation (Demessie *et al.*, 2013). In central Senegal on Luvisols and Arenosols, total SOC stocks were 27% to 37% lower in groundnut fields with an age attaining 25 years compared to savannahs (Touré *et al.*, 2013). On Ferralsols in central Malawi (Walker and Desanker, 2004), SOC stocks were40% lower in agricultural fields with a maximum age of 30 years than in Miombo woodlands. In NE Namibia, Luther-Mosebach (2017) also reported lower SOC stocks in old agricultural fields compared to woodland, with differences in SOC stocks between agriculture and woodland being a maximum of 39%. Possible reasons for the SOC losses are the reduced inputs of organic material in agricultural soils and enhanced mineralization rates as a result of soil disturbances from tillage.

The pH (H_2O) and the phosphatase acid activity of the soil showed a slight decrease with time of cultivation. However, this drop was not significant (P<0.05). In effect, soil is a buffer medium and consequently opposes any extreme pH fluctuations. The slight decrease of the pH observed might be due to the presence of cations like Al^{3+} or progressive accumulation of nitrogen fertilizer residues (Chidumaya, 1999). In effect, microbial action on nitrogen fertilisers leads to the production of nitric acids. This strong acid completely ionises in soil solution liberating H^+ ions responsible for soil acidity.

The electrical conductivity (EC) was significantly affected by long term cultivation. The strong increase in EC observed during the first year might be due to ash derived from slash and burn or irrigation water or even to the excessive use of natural or chemical fertilizers (Murtaza *et al.,* 2008; Fotio *et al*., 2013). The decomposition of organic matter by micro-organisms liberates ions like Na^+, Ca^{2+}, Mg^{2+}, NO_3^-, CO_3^{2-}, HCO_3^{2-}, SO_4^{2-} where part is absorbed by the plant and the excess accumulates in the soil causing soil salinity. Residues of chemical fertilizers which are soluble salts increase the concentration of those chemical in soil contents of the soil. Also, irrigation water always contains a certain quantity of salt. When the water finally evaporates or is absorbed by vegetation, the salt remains in the soil. These findings agree with those of Marlet (2004) and Magro (2006). The gradual decline of the EC observed later on could be the result of the salt leaching by rain water. Enzyme activities are often used to determine the effects of pollutants on the microbiological status of soil (Ascoli *et al*., 2006). The decrease of the phosphatase acid activity with time of cultivation was not significant (P<0.05). In effect, this extra cellular enzyme is generally protected from degradation by being adsorbed on the surfaces of clay minerals and humic substances. Also, the continuous production of this enzyme by plant roots can be responsible for its insensitivity with respect to pesticides and fertilizers (Boyd and Martland, 1990).

The gradual drop in the dehydrogenase activity observed might be due to the progressive destruction of part of the soil microflora by pesticides and fertilizers. Perhaps, the works of Jäggi *et al*. (2002); Dilly *et al*., (2002); Maurer *et al.*, (2004) showed that at long term (10 years), soil tilling with food crops without chemical inputs do not significantly affect the soil biomass and respiration. Also, dehydrogenase is an intracellular enzyme found in living cells associated with respiratory functions. Its presence in the soil reflects the presence of active micro-organisms such as bacteria and fungi (Tabatabai, 1994). The decrease in dehydrogenase activity has also been reported by Monkiedje and Spiteller (2002); Monkiédje *et al.* (2002) and Demanou (2005) following fungicide application. Koper and Piostrowska (2003) also reported similar results following the continuous and long-term application of NPK and organic fertilizers.

The reduction of organic carbon was slight but gradual. It might be due to soil tilling without subsequent adequate plant residue management (exportation of plant residues). The frequent tilling of soils increases the accessibility of organic matter to micro-organisms. However, the observed decrease of the dehydrogenase activity permits to neglect the possibility of organic carbon mineralisation

Ammonium dropped drastically (86%) after the first year, passing from 6.8 ± 2.4 ppm in the control to below detection level after 10 years of continuous cultivation. The available phosphorus contents decreased gradually. Considering that soil tilling favours the accessibility of organic matter to microorganisms for decomposition and for same reasons evoked above, the observed decrease in exchangeable ammonium and available phosphorus might be attributed to the use of pesticides and fertilizers. The decrease in the quantity of organic matter to be mineralised cannot be evoked here considering the fact that it is not much. As for exchangeable ammonium, the observed decrease was undoubtedly associated to the increased production of nitrates or the inhibited growth of ammonifying bacteria by pesticides and fertilizers. By comparing this result with that of electrical conductivity, the cause related to the production of nitrates is more acceptable. Also, Zafar *et al.*, (2001) showed that the association of many pesticides applied at long-term in a cotton plantation stimulated nitrification. Monkiédje *et al*. (2002) also reported a stimulation of nitrification in soils treated with fongicides mefenoxan and metalaxyl, respectively. In effect, the primary substrate for nitrifying bacteria is ammonia.

The decrease in available phosphorus might have been controlled by progressive inhibition of micro-organisms promoting phosphorus mineralisation as well as fertilizers. These results were very similar to those of Defo (2003) and Demanou (2005) on the application of Endosulfan and Ridomil Gold Plus, respectively. Dumestre *et al*., (1999) documented that the effects of copper contamination on the general structure of soil microbial bacterial communities was still evident 50 after fertilizer application.

The significant positive correlation amongst OC, available P, exchangeable ammonium, phosphatase acid and C/N ratio in the control soil is evidence that all these organic components are linked to soil organic matter (Dilly *et al*., 2002). After continuous cultivation, the sharp drop in correlation coefficients among most of those parameters might imply a depletion of organic matter by rapid mineralization as evidenced by the very low C/N ratio (<12) for all the treatments (Thiombiano and Dianou, 1999).

CONCLUSION

The aim of this study was to assess the effect of continuous intensive cultivation on the chemical and microbiological properties on Oxic Dystrandept soils in the Western Highlands of Cameroon. The main results revealed that farmers practiced intensive cultivation of food crops. For more than a decade, they have used fertilizers and pesticides on their farmlands with the consequence that the fertility of these soils has declined drastically today. In the present farming conditions of the soil there is slight decrease in organic carbon. The soil inputs used might have destroyed part of the soil flora and fauna, thus significantly and progressively affecting the soil quality indices (available phosphorus, exchangeable ammonium dehydrogenase activity, electrical conductivity). Conversely, pH and phosphatase acid activity were not significantly affected by the intensive farming practice even after 10 years of continuous cultivation. The significant action of the intensive agriculture on the soil quality indices might have been at the origin of soil fertility reduction in this area. Thus, at this declining rate, the soils of this agroecological zone might become almost unproductive, and necessitating management strategies like selection of suitable cropping systems and chemical methods (right amounts and combination of nutrients).

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