African Crop Science Journal, Vol. 12. No. 2, pp. 163-170, 2004
ISSN 1021-9730/2004 $ 4.00

SHORT COMMUNICATION

ASSESSING SOIL CHEMICAL FERTILITY IN HOMEGARDENS IN FORESTED AREAS OF SOUTHERN CAMEROON

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(Received 14 March, 2001; accepted 16 February, 2004)

ABSTRACT

It is argued that appropriate management of homegardens is critical for their sustainable productivity. In southern Cameroon, this management consists of hand-hoeing the soil when grown to food crops and using no-tillage when grown to fruit trees, and ensuring of crop and weed residues, household refuse, wood ash, farmyard manure whenever available instead of mineral fertilisers. However, the effect of these practices on the soil chemical fertility in different types of homegardens is largely unknown. A comparison was made between soils from secondary forest (SF) in three blocks, and the corresponding homegarden types (HT). The three blocks selected from north to south along a declining population gradient were Yaoundé (block 1), Mbalmayo (block 2) and Ebolowa (block 3). The HTs were defined as HT1 characterized by the dominance of crops whose growing cycle seldom exceeds 3 months, HT2 dominated by annual and semi-perennial food crops, and HT3 mainly constituted of tree crops. The soil characteristics evaluated were organic carbon (OC), total N, exchangeable bases, exchange acidity and pH. The level of soil parameters evaluated were comparatively higher in HTs than in SFs. Generally, OC, N, sum of exchangeable bases and pH were rated as low (32 g kg^{-1}), medium (2.2 g kg^{-1}), high (14 cmol kg^{-1}) and medium (6.7), respectively in HTs whereas in SFs, OC was rated as very low (17.8 g kg^{-1}), while N (1.7 g kg^{-1}), sum of exchangeable bases (3.28 cmol kg^{-1}) and pH (4.9) were rated as low. Besides, whereas the sum of exchangeable bases, the exchange acidity and OC differed significantly among blocks in SFs, no significant difference was found in HTs within and between blocks, suggesting that the differences observed among the SF's soils could be removed following the application of homegarden-managed techniques and result in sustainable agriculture in the forest zone.

Key Words: Exchangeable bases, forest zone, homegarden types

RÉSUMÉ

On soutient que une gestion adéquate de champs autour de la cour est critique pour une productivité durable. Au sud du Caméroun cette gestion consiste au sarclage à la main quand il s'agit de cultiver des plantes et l'usage du non labour quand il s'agit des arbres fruitiers, d'assurer des residus des plantes et des mauvaises herbes, des ordures ménagères, du cendres de bois quand disponible au lieu des engrais minéraux. Cependant, les effets de ces practiques sur la fertilité chimique dans différents champs de cours sont largement inconnus. Une comparaison était faite entre les sols de la forêt secondaire (FS) en trois blocs et les champs de cours (CC) correspondants. Les trois blocs étaient sélectionnés du north au sud le long d' un gradient de population: Yaoundé (bloc), Mbalmayo (bloc 2) et Ebolowa (bloc 3). Les (CC) étaient définis comme CC1 caractérisé des plantes dont le cycle de culture dépasse rarement 3 mois. Les CC2 étaient dominés par des plantes annuelles et semi-vivaces.

Les CC3 étaient constitués par des plantes arbitieux. Les paramètres du sol évalués étaient le carbone organique, l'azote total, les bases échangeables, l'acidité échangeable et le pH. Le niveau des paramètres du sol évalués étaient plus élévés dans le CC que dans les FS. Généralement, le niveau du carbone organique, l'azote, la somme des bases échangeables et le pH était faible (32 g kg^{-1}), modéré (2.2 g kg^{-1}), élévé (14 cmol kg^{-1}) et modéré (6.7) dans les CC . Il était très faible (17.8 g kg^{-1}) pour le carbone organique, alsor qu'il était faible pour l'azote (1.7 g kg^{-1}), la somme des bases échangeables (3.28 cmol kg^{-1}) et le pH (4.9). En plus, la somme des bases échangeables, l'acidité échangeable et le carbone organique varié significativement avec les blocs dans les FS. La différence n' a pas été trouvée significative entre et à l'intérieur de chaque bloc pour les CC, suggérant que les différences observées dans les sols des FS pourraient disparaître après l'application des techniques de gestions de champs de cours pour une agriculture durable dans la zone forestière.

Mots Clés: Bases échangeables, zone forestière, champs des cours

INTRODUCTION

For food production, farmers in the humid tropics generally rely on the traditional shifting cultivation practices for food production (De Schlippe, 1956; Concklin, 1957; Pelzer, 1958; Nye and Greenland, 1960; Watters, 1960 a, b; Ahn, 1970; De Leener *et al.*, 1981; Koto Kanno, 1983; Leplaideur, 1985). In southern Cameroon however, food obtained through shifting cultivation is frequently supplemented by agricultural produce from homegardens. Homegardens are any agricultural land-use systems located around the house that makes use solely of family labour and integrates in the same plot annual (herbaceous), semi-perennial and perennial (woody) crops, and/or animals (Tchatat, 1996). While in shifting cultivation the farm is abandoned and allowed to rest in fallow for several years (2 - 20 years) after only two cropping seasons to recover its fertility and productivity (Nye and Greenland, 1960; Ahn, 1970; Tonyé *et al.*, 1987), the practice of homegarden is said to be sustained over a long period with little or no use of mineral fertilisers (Tchatat *et al.*, 1996) depending on their past and present management. Most studies conducted in the tropics on homegardens have focused on their socio-economic (Kimber, 1973; Jacob and Alles, 1987; Asare *et al.*, 1990; Thaman, 1990) and floristic aspects (Christanty, 1990; Caballero, 1991; Nair, 1993), and the determination of their structure, composition (Christanty, 1981; Fernandes and Nair, 1986), management and function (Wiersum, 1988; Abdoellah, 1990). There is limited information on the situation of the soil fertility status in this agricultural system. This study was conducted to compare soil chemical characteristics across and between homegarden types and diverse fields in fallow land and secondary forest.

MATERIALS AND METHODS

The sites and the soils. The study was conducted in 3 forested areas following a population gradient stretching from the northern limit of Cameroon's forest zone to the border with Equatorial Guinea and Gabon (Fig. 1). The Yaoundé block (block 1) has high population density (88 inhabitants km^{-2}) (Gockowski, 1996) with high pressure on land. The soil which is developed on migmatitic gneiss is classified as Ferric Acrisol (FAO,1998), has medium texture in the topsoil and clayey texture in the subsoil. The exchangeable Al content is very low (negligeable) and the pH is slightly acid. Furthermore, the OC content is moderate whereas the total N and available Bray 2-P level is usually low and very low respectively (Landon, 1984).

Contrary to the preceding block, the Ebolowa area (block 3) is low populated (15 inhabitants km^{-2}) (Gockowski, 1996) with little or no pressure on land. The soil developed on charnockite rock is classified as Aluminic Acrisol (FAO, 1998), the profile is clayey in texture exhibits an acidic to strongly acidic reaction as a result of high exchange acidity (Al^{3+} + H^+). While the OC and total N content is low, the available P (Bray 2) level is moderate (Landon, 1984).

Mbalmayo is a transitional block (block 2) between Yaoundé and Ebolowa (Fig. 1). It is a medium populated zone (44 inhabitants km^{-2}) (Gockowski, 1996), with an intermediate pressure on land. The soil is a Ferric Acrisol (FAO, 1998) as in Yaoundé, except that the topsoil is sandy-loam or loamy-sand in texture due to the parent material dominated by schists and the sum of exchangeable bases is higher. The remaining soil properties are similar to those of Yaoundé soils.

The overall region has a sub-equatorial climate (Suchel, 1972; Moby-Etia, 1979). The average annual rainfall ranges from 1300 to 2500 mm and occurs in a bimodal configuration such that the major and minor cropping seasons last from mid-March to early July and from mid-August to mid-November, respectively.

The sites and the prevailing homegardens. The main criterion used to discriminate homegarden types (HT) was their composition as differentiated after the dominant crops group (i.e., the group with the largest vegetative cover). Prior to this exercise, three crop groups were classified according to their biological cycle based on the floristic survey accomplished in the study sites. The first group was based on maize (*Zea mays* L.) whose growing cycle seldom exceeds 3 months. Maize may have companion crops such as groundnut (*Arachis hypogaea* L.) or bean (*Phaseolus vulgaris* L.). The second group was made up of annual and semi-perennial food crops such as cocoyam (*Xanthosoma sagittifolium* (L.) Schott), plantain (*Musa* sp. AAB Colla), cassava (*Manihot esculenta* Crantz), and the third group was mainly constituted of tree crops like African plum (*Dacryodes edulis* (G. Donf.) H.J. Lam), mango (*Mangifera indica* L.), and coconut (*Cocos nucifera* L.) (Tchatat *et al.*, 1996). No mineral fertiliser was applied but rather crop residue, household refuse including wood ash, and farmyard manure wherever available (Table 1).

Thus, although each HT may grow crops from any of the above defined crop groups, type-1 homegarden (HT1) was characterized by the dominance of crop species from group 1, whereas types 2 (HT2) and 3 (HT3) were dominated by crops from group 2 and 3, respectively. The HT2

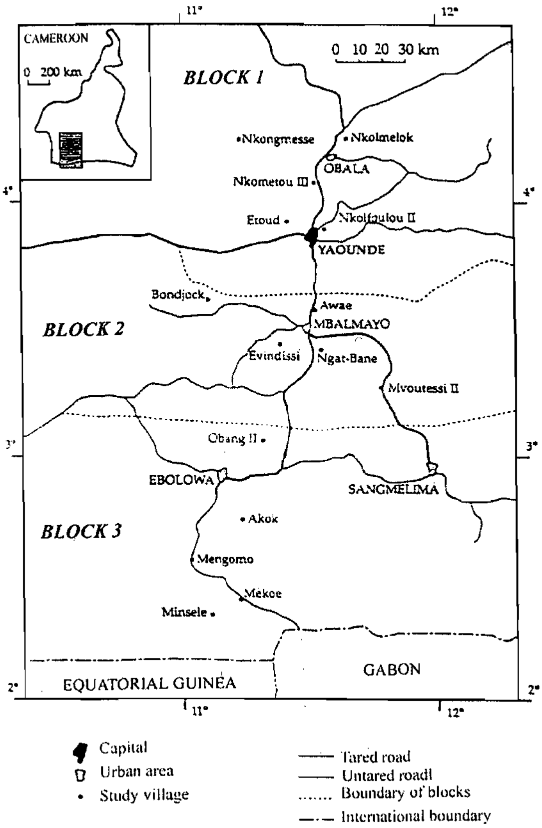

Figure 1. Sites in which the study was conducted.

and HT3 homegardens are represented in the 3 blocks while HT1 is found only in the Yaoundé block. In addition, the average homegarden size differed from one block to the other block 1, block 2 and block 3 with 0.16, 0.18 and 0.21 ha, respectively.

The field study. A factorial experiment in a split-plot design has been used to facilitate the comparison. The main-plot factor was crop species (CS) and comprised food crops (FC) and fruit trees (FT). The subplot factor was the homegarden types (HT1, HT2, and HT3) as described earlier. In each block, four villages were randomly selected among 15 representative villages of the block using the random numbers table and served as replicates. Composite soil samples were collected from each sub-treatment along a cross-shaped transect at 0-15 cm depth using an Edelman soil auger. This exercise yielded a total of 56 composite samples. The samples were air-dried before grinding, then used to evaluate the fertility factors such as organic carbon (OC), total N (N), exchangeable bases, and pH_{H2O} (1:2.5), to be compared with those from the nearby secondary forest in each block (Table 2) where composite samples were randomly collected at the same depth.

Means of pH values and nutrient content were determined. Statistical analyses were performed to determine the difference in nutrient (OC, N, Ca, Mg, K) content among the HTs and between the areas under homegardens and under secondary forest, using Systat software (Systat, Inc., 1988).

RESULTS AND DISCUSSION

Based on the topsoil data shown in Table 2, the three blocks as described above could be ranked as good to medium after Dabin's rating (Dabin,

TABLE 1. Percentage of families using soil amendments in each block*

Types of amendment	Blocks		
	Yaoundé (B1)	Mbalmayo (B2)	Ebolowa (B3)
Crop residues	59	81	61
Household refuse	36	75	41
Wood ash	12	49	19
Farmyard manure	5	0	0
Inorganic fertilisers	0	0	0
Others	0	0	0

* N = 96 families, with 32 families per block, and some families used more than one type of amendment at the same time

TABLE 2. Variation of selected topsoil (0-15 cm) properties in secondary forest (SF) across blocks

Block	Location	Soil properties				
		pH (1:2.5)	SEB* ($cmol\ kg^{-1}$)	EA ($cmol\ kg^{-1}$)	OC ($g\ kg^{-1}$)	N ($g\ kg^{-1}$)
B1	Yaoundé	5.0	2.55	0.02	21.4	1.8
B2	Mbalmayo	5.3	6.00	0.00	17.8	1.5
B3	Ebolowa	4.4	1.28	3.29	14.3	1.9
Mean		4.9 L**	3.28 L	1.10	17.8 vL	1.7 L
SD (Standard dev.)		-	2.44	1.89	3.5	0.2
CV %		-	74	172	20	12

* SEB = Sum of exchangeable bases; EA = Exchange acidity (Al^{3+} + H^{+}); OC = Organic carbon; N = Total nitrogen
**Ratings of nutrient status: L = low; vL = very low (Landon, 1984; Euroconsult, 1989)

1961) as follows: block 1 ≈ block 2 > block 3. Although no significant differences were found among the three blocks in pH and N content, they differed significantly with respect to OC, sum of exchangeable bases and exchange acidity levels (Table 2). Thus, it is likely that the differences existing between the parent rocks were more or less reflected in the soils in secondary forests (SFs), hence the significant difference found among blocks. However, contrary to expectations, this was not reflected by the homegardens' soil characteristics as shown in Table 3(a - c).

Homegarden-managed techniques, in a few cases, resulted in significant difference ($P<0.05$) occuring between main plots (CS) but in general, no significant difference was found among subplots homegarden types (HTs) (Table 3). Although through use of the homegarden-managed techniques it is possible to identify soil chemical characteristics over time, this standard procedure exhibited variations within the forest zone.

In block 2 for instance, CS management resulted in higher values of almost all the nutrients in FTs than FCs, particularly OC, N and Mg whose

TABLE 3. Comparison of topsoil (0-15 cm) pH, OC, N, Ca, Mg, K, in the different types of homegarden (average of four replications or villages)

Treatments*		pH	OC(g kg^{-1})	N(g kg^{-1})	Ca(cmol kg^{-1})	Mg	K
a) Block 1							
HT	HT1	6.7	23.9	1.9	9.38	1.52	0.54
	HT2	7.1	26.7	2.2	12.14	2.73	0.83
	HT3	6.6	22.0	1.9	9.05	1.66	0.62
	FC	7.2	24.4	2.0	11.17	2.24	0.73
CS	FT	6.4	24.0	2.0	9.21	1.70	0.53
$LSD_{0.05}$	HT	-	7.4 ns	0.7 ns	5.23 ns	1.18 ns	0.53 ns
$LSD_{0.05}$	CS	-	3.5 ns	0.4 ns	2.81 ns	0.92 ns	0.36 ns
$LSD_{0.05}$	HT x CS	-	6.0 ns	0.6 ns	4.87 s	1.60 ns	0.63 ns
b) Block 2							
HT	HT1	-	-	-	-	-	-
	HT2	6.6	41.9	2.0	11.17	1.90	0.50
	HT3	7.1	43.1	2.1	12.13	2.20	0.67
	FC	6.9	34.5	1.8	10.02	1.32	0.50
CS	FT	6.8	50.5	2.4	13.28	2.78	0.67
$LSD_{0.05}$	HT		23.8ns	1.0 ns	10.91 ns	2.53 ns	0.52 ns
$LSD_{0.05}$	CS	-	8.2 ns	0.3 ns	6.79 ns	1.43 ns	0.26 ns
$LSD_{0.05}$	HT x CS	-	6 ns	0.4 ns	9.60 ns	2.05 ns	0.37 ns
c) Block 3							
HT	HT1	-	-	-	-	-	-
	HT2	6.5	28.3	2.5	10.95	2.22	0.71
	HT3	6.5	30.5	2.2	12.61	2.69	0.65
	FC	6.8	30.2	2.4	12.64	2.85	0.79
CS	FT	6.2	28.6	2.3	10.92	2.06	0.57
$LSD_{0.05}$	HT	-	9.6 ns	0.4 ns	7.40 ns	2.11 ns	0.44 ns
$LSD_{0.05}$	CS	-	5.1 ns	0.2 ns	5.28 ns	1.87 ns	0.53 ns
$LSD_{0.05}$	HT x CS	-	7.2 ns	0.35 ns	7.46 ns	2.64 ns	0.76 ns

*CS = crop species; FC = food crops; FT = fruit trees; HT = homegarden type; LSD = Least significant difference; OC = organic carbon levels were significantly different ($P<0.05$) (Table 3b). The explanation given in this case for the advantage of FTs over FCs was that perennials in general and fruit trees in particular generate more biomass (litter) in a continuous manner as compared to annuals (Nair, 1993). However, this does not hold true for blocks 1 and 3 where one may observe lower values of soil fertility indicators in FTs as compared with FCs (Table 3a,c). Besides, in SFs, although a lot of biomass is produced continuously, soil nutrients level does not exceed the one of homegardens as measured in this study (Table 4). The reason behind the high value of any soil parameter (conversely low, when it refers to exchange acidity) obtained in this study should be similar to the rates presented in Table 1 and frequency of application of the different types of soil amendments. The different soil amendments were mostly used in block 2 > 3 and 1 in this order (Table 1). The contribution of crop residues, household refuse including wood ash, and farmyard manure in enhancing soil fertility is well documented (Pereira and Jones, 1954; Kumwenda *et al.*, 1995; Donovan and Casey, 1998).

Results in Table 4 reveal that the standardisation of soil chemical properties mentioned above is one of the advantages that accrue from homegarden-managed techniques. In fact, no significant differences were found between blocks for all the soil parameters considered except OC content due to its high value in FTs in block 2. All the soil parameters were consistently higher in HTs than SFs probably as a result of frequent amendments application in the SFs. Sum of exchangeable bases, pH, OC, and N were rated as high, medium, low and medium, respectively in HTs whereas in FCs, OC was rated as very low while N, sum of exchangeable bases and pH were rated as low (Landon, 1984; Euroconsult, 1989). Moreover while the sum of exchangeable bases, the exchange acidity and OC differed significantly among blocks in SFs, no significant difference was found in HTs within and between blocks. This suggests that the differences that were observed between the soils on secondary forests (i.e., the different soil units) may be removed if they were to be managed as homegardens.

CONCLUSION

This study was initiated to assess and compare soil chemical properties across three types of homegardens. It was also aimed to compare soils on secondary forests and on homegardens. The results showed that the level of soil fertility was comparatively higher in homegardens than secondary forests. Besides, the differences observed from the start between secondary forest's soils were completely removed as a result of homegarden management which led to the standardisation of soil chemical characteristics within and across blocks. This suggests that homegarden-managed techniques may serve as an alternative to slash-and-burn agriculture and a solution towards sustainable agriculture in the forest zone of Cameroon.

TABLE 4. Comparison of selected topsoil (0-15 cm) properties in homegardens across blocks

Block	Location	Soil properties*				
		pH(1:2.5)	SEB(cmol kg^{-1})**	EA	OC(g kg^{-1})	N
B1	Yaoundé	6.8	12.79	0.00	24.2	2.0
B2	Mbalmayo	6.9	14.29	0.00	42.5	2.1
B3	Ebolowa	6.5	14.92	0.00	29.4	2.4
Mean		6.7m***	14h	0.00	32 L	2.2 m
SD (standard dev.)		-	1.09	-	9.4	0.2
CV (%)		-	8	-	29	10

* Average of 2 HTs for blocks 2 and 3 and 3 HTs for block 1
** SEB = sum of exchangeable bases; EA = exchange acidity; OC = organic carbon; HT = homegarden type
***Ratings of nutrient status: h = high; L = low; m = medium (Landon, 1984; Euroconsult, 1989)

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