Research Journal of Agriculture and Biological Sciences, 3(6): 907-916, 2007

Soil Degradation in the Sudano-guinea Savannas of Mbe, Cameroon: Farmers' Perception, Indicators and Soil Fertility Management Strategies

[1]Ibrahima Adamou, [2]Nguetnkam Jean Pierre, [1]Pabame Pogenet,
[1]Beunon Tchimbi and [1]Guidawa Gonlaina

[1]1Departmentof Biological Sciences and 2Department of Earth Sciences,
Faculty of Science, University of Ngaoundere, P.O. Box 454 Ngaoundere, Cameroon.
University of Ngaoundere, P.O. Box 454 Ngaoundere, Cameroon.
[2]Department of Earth Sciences, Faculty of Science,
University of Ngaoundere, P.O. Box 454 Ngaoundere, Cameroon.

Abstract: A survey was carried out in the humid savannas of Mbe to assess farmers' indigenous knowledge of soil fertility, their indicators and management strategies of natural resource. A sample of 174 households was chosen at random in three farming villages in this region. Findings showed that the farmers refer to a group of biological and physical indicators before working a piece of bushland or in assessing the fertility of farmland. The fertility indicator plant species are essentially *Terminalia macroptera* (11.39% of the responses), *Pennisetum purpureum* (11.29%), *Rottboellina cochenchinensis* (11.19%), those indicating poor soil include *Striga hermontica* (40.90%), Tridax procumbens (25.60%). Faunal indicative of soil fertility are the earthworm (35.29%) and termites (29.41%). Black soil (50.95%) and the presence of earthworm casts (30.24%) indicate soil fertility while sandy soils (49.05%) indicate poorness of soil. The farmers maintain and /or improve on the soil fertility by practising various types of crop rotation, making ridges as well as using household waste and animal manure. Bush fallowing however plays an important role in traditional farming systems. Now some management strategies are needed to be modified and adapted before they become effective. This should be based on a thorough knowledge of farmers.

Keywords: Soil fertility, farmer indicators, management, savannas of Mbe, Adamawa, Cameroon

INTRODUCTION

In spite of the fact that agricultural activities are given priority in Cameroon, the problems of food insecurity remains acute, especially in the northern part, even though the occupation of the majority of the people is crop cultivation and animal rearing[1]. Shifting cultivation is general described as a sustainable farming system in sparsely population areas, as farmers can allow long restorative fallow periods. It has been practiced over decades throughout the savannas areas, particularly in the sudano-guinea savannas of Adamawa Cameroon, with less than 9 inhabitants per km^2[2]. Traditional farming systems, based on slash and burned agriculture and long fallow periods, is inadequate today to guarantee sufficient production and maintain natural resources in a sustainable manner. Fallow duration is limited to between 3 and 5 years, as reported in the Adamawa region of Cameroon[2]. With the present day problem of demographic pressure and the advent of immigrants from the Far North province of Cameroon in search of fertile lands, farmers are confronted with the problem of reduced arable land and increasingly find it difficult to practice natural fallowing whose effectiveness can only be after 10-15 years[2,3]. Then significant changes in land uses are noticeable over the savannas zone. The recent economic crises in Cameroon coupled with fallen cotton prices in the world market consequent upon poor subvention practices of European and American agriculture[4], and the cessation of state subsidies on farm inputs, forced farmers to abandon modern agriculture in the Adamawa region and look for other income-generating opportunities, mostly food crop production, Non Timber forest products (NTFP). Many state employees who lost their jobs or faced salary cuts increased their activity in food crop production to compensate for the lost income. This led to a very significant increase in savannas clearing with its attendant profound negative environmental consequences[1]. More specifically for the

Corresponding Author: Ibrahima Adamou1, Department of Biological Sciences, Faculty of Science, University of Ngaoundere, P.O. Box 454 Ngaoundere, Cameroon.
E-mail: aibrahima@hotmail.com

Mbe subdivision in the Adamawa region of Cameroon, farmer abandoned modern agriculture and turned to intensive cutting woods for charcoal and hunting in the forest reserve. Restricted access to the natural resources of the forestry reserve, forced farmers to intensify food crop production in the buffer zone. Also the creation of the University of Ngaoundere in 1993 and the large settlement zone around agro- industrial complexes (MAISCAM) increased the demand for food crops.

The driving forces mentioned above resulted in intensification of food cropping and changes in land use systems, especially shorter fallows, which led to declining soil fertility and land degradation, resulting in increasing constraints on local people's livelihoods. Information about farmers' perception of soil fertility, indicators and the importance they attach to it may be useful when searching for new technologies or improving exiting ones to overcome nutrient deficiencies[5], with less negative environmental, biological and agronomic effects. This information is not available in the humid savannas of the Adamawa region, especially in the Mbe subdivision. Hence, this paper attempts to identify indicators that are consistent with farmers' perception of soil fertility and then assess farmers' strategies in response to these changes, and make a link between their strategies and soil fertility restoration.

MATERIALS AND METHODS

The Study Site: The study was conducted in the agricultural buffer zones of the humid savannas of Mbe in central North Cameroon. The site is in the Vina Division along the Ngaoundere-Garoua national highway, 70 km from Ngaoundere. It lies between 7°35' and 13°49' latitude North and between 13°41' and 13°44' longitude East. The climate is the humid sudano-guinea type according to Suchel[6], with a unimodal rainfall distribution. Mean annual rainfall is 1400 mm. The rainy season extends from July to September, registering maximum amounts in August. The dry season stretches from November to March. The mean annual temperature is 22°C. The ferralitic soils are the dominant types[7], with low organic matter (less than 1%), low soil exchange capacity from 15 to 20 meq/100g and the pH about 4.7 to 5.6. Hydromorphic soils are found in the marshy depressions. The vegetation of Mbe is a humid savannas with *Isoberlinia doka, Afzelia africana* and *Anogeissus leiocarpus*, including dense stands of *Monotes kerstingii*, *Parinari curatellifolia*, and *Uapaca togoensis*. There are also hydromorphic prairies that are sometimes inundated and containing *Hypparhenia rufa,* forest galleries with *Syzygium guineense* var. *guineense* and *Berlinia grandifolia*, degraded fallow lands and savannas occasionally used as grazing land and composed of *Acacia hockii*, Afzelia africana[8].

The population of Mbe subdivision is about 13500 with 7800 farmers, that is, more than 50 % of the total population[9]. This population is cosmopolitan and composed of the Dii (or Dourou), Mboum, Laka, Fulani, Toupouri and Kim. The dominant tribe is the Dii (92 %), who with the Mboum constitute the natives. The main crop is yam with a yield of 12-62 t/ha, followed by corn and cassava with respective yields of 2-3 and 3 t/ha. Cotton, a cash crop, groundnut, and millet are cultivated to a small extent, with yields that rarely attain 1 t/ha. Other activities like poultry, bovine and pig farming, hunting, fishing and crafts are practised at artisan scale in the region. The most crucial of the region's problems include the steady fall in soil fertility, damages caused by striga on cereals, by the partridge and ruminants on seedlings and by termites on crops (yellowing and fall of yam leaves).

Description of the Questionnaire: The research methodology was based on interviews using open-ended questions and on field observations. The survey was conducted from May to October 2002, within the context of the Support to Integrated Development Programme (PADI), whose role is to guide farmers. The sample unit was the farm household with the head of the household as the respondent. The sample was made up of persons of both sexes and of different ages (Table 1), distributed over the entire population (particularly the indigenous): the full-time farmers (more than 50 %) and part-time farmers, that is, those who associate agriculture to other activities like animal rearing, commerce, fishing and teaching. Strangers who had not made up to 10 years in the region were excluded from the sample, because we assumed that they know little or do not know enough about the local cultural systems. A questionnaire was offered to a semi-random sample of 174 households in the three most crowded and agricultural villages of Man, Mbe and Wack. The main focus was the farmer's concept of soil fertility and soil fertility management strategies. Questions were asked to individuals or to groups on the farmer's concept of fertility, his perception of soil degradation, what they consider to be indicators of soil fertility and how they manage soil fertility.

RESULTS AND DISCUSSIONS

Results:

Farmer's Concept of Soil Fertility: Generally, the term fertility in the literal sense of the word does not exist in the languages of the tribes involved in the study. However, these people have expressions that they use to define the concept of soil fertility (Table 2). For most of the tribes, one expression is used, namely, *teciri bella* for the Mboum and *taa bay* for the Toupouri. On the other hand, the Dii (Dourou)

Table 1: Distribution of sex and age of farmers in the three villages of Mbe sub-division

Villages	Total	Sex		Ages		
		Male	Female	25 – 40	41 - 60	> 60
Man	13	10	3	9	1	3
Mbe	83	54	29	36	37	10
Wack	78	61	17	37	27	14
Total	174	125	49	82	65	27

Table 2: Expressions used by farmers to indicate soil fertility in the Mbe region and their translation (% of responses*).

Ethnies	Expression	Response (%)	Expression	Response (%)	Expression	Response (%)
Dii (Dourou)	Hack-ké	50.00	Hack-dii	28.74	Hack-koun	13.22
Mboum	Teciri bella	4.00	-	-	-	-
Toupouri	-	-	Taa bay	1.15	-	-
Translation	Good soil	54.02	Black soil	29.89	Soil having oil	13.22

* Sums below 100% are due to no reply.

use three expressions indifferently, the most common being *hack-ké* (50% of the total responses). The following translations of expressions in the local languages, *good soil (teciri bella in Mboum* and *hack-ké* in Dii) are the most frequently used (54.02%), followed by *black soil and soil that has oil* with 29.89% and 13.22% of the total responses respectively.

Farmers' Indicators of Fertile and Poor (Or Infertile) Soils: To determine fertile soils, the farmers of Mbe use indicators that we grouped under two main types: the biological and physical (Figure 1). The biological indicator made up of flora and fauna, and the physical one included physical characteristics of the soil, earthworm casts and the presence of termite hills (Table 3). Plant indicators were much more numerous and varied than the animal ones. The sampled plant species fell within eight families of which the widely known and most commonly used were the *Poaceae* (39% of farmers' responses), the *mimosaceae* (21.73%) and the *combretacea* (13.04%). The other families were scarcely mentioned (<10%) as indicators of soil fertility. Plant species did not all have the same importance as soil fertility indicator (Table 3). Apart from four species (*Lannea schimperi, Entada africana, Anogeiossus leiocarpus and Chromolaena odorata*) whose percentage of response was less than 3.5%, all the others, especially the gramineae and one tree *Terminalia macroptera*, constituted an important, most commonly used index.

Like flora, fauna was also used by the farmers of Mbe as indicators of soil fertility (Table 3). However, according to their direct or indirect role in soil fertility, the farmers distinguished between the pedo-fauna or soil fauna (66.59%) that intervened directly in soil fertility and macrofauna (33.41%). Among the animal

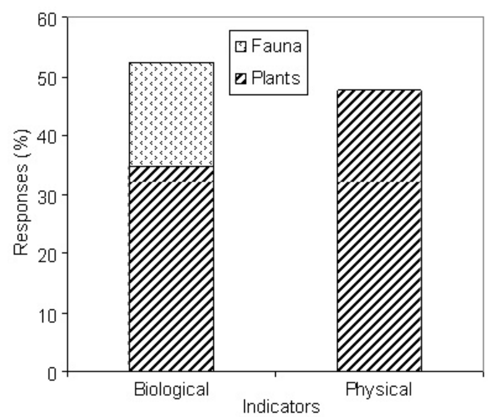

Fig. 1: Mains Farmers' indicators of soil fertility in Mbe humid savannas

species that contribute directly to soil fertility, the earthworms (34.78%), and termites (31.81%) were the most commonly known and valued by the farmers. More than 95% of the farmers claimed that the abundance of earthworms in an arable land is an index of soil vitality or soil fertility, adding that such soil type is particularly convenient (13.11%) for the cultivation of cereals like rice, millet and corn. Big fauna, including elephants, rabbits, partridges, antelopes, hedge-hogs, squirrels and deer contribute to soil fertility through their droppings, but especially seek, in an abundant vegetation cover, food (49.42%), shelter and refuge (50.58%) from predators.

The farmers did not only use biological criteria to make out fertile land, but associated physical characteristics to these criteria (Table 3). The most important of these (physical characteristics) were black soil (30.96%) and earthworm casts (30.25%). To these characteristics, they added termite

Table 3: Farmers' indicators of soil fertility in the traditional land uses of Mbe Adamawa - Cameroon. (% of responses).

	Vegetation indicators		Animal indicators		Physical indicators	
Scientific name	Family	Responses (%)	Name	Responses (%)	Soil characteristics	Response (%)
Ardropogon gayanus	Poaceae	11.08	earthworms	34.78	Black soil	30.96
Imperata cylindrica	Poaceae	10.47	Termites	31.81	Earthworm casts	30.25
Loudetia flavida	Poaceae	9.13	Elephants	10.29	Termite hill	15.48
Pennisetum polystachion	Poaceae	10.06	Hedgehogs	6.17	Soil texture	11.93
Pennisetum purpureum	Poaceae	11.29	Rabbits	4.94	Soil compactness	11.38
Rottbollina cochinchinensis	Poaceae	11.19	Squirrels	4.34		
Acacia polyacantha	Mimosaceae	8.54	Partridges	3.97		
Entada Africana	Mimosaceae	0.82	Deers	2.97		
Anogeissus leiocarpus	Combretaceae	1.5	Antelopes	0.68		
Terminalia macroptera	Combretaceae	11.39				
Isoberlinia doka	Caesalpiniaceae	10.16				
Lannea schimperi	Anacardiaceae	0.61				
Chromolaena odorata	Asteraceae	3.5				

Poaceae (39%); Mimosaceae (21.73%); Combretaceae (13.04%) and other families (26.23%)

hill (or white ant hills), unctuousness and compactness of the soils as well as stickiness of the soil to the hands. More than 96% of the farmers interviewed thought that soil with earthworm casts is particularly fertile and the land around a termite nest is most often solicited for growing cereals, okra and melon.

To measure the degree of soil poorness or infertility, Mbe farmers based their judgement on a series of biological indicators that are linked to the state of the soil (Table 4). However, criteria indicating infertile soils are very few. Plant indicators of *soil tiredness* are not very diversified. Three of these species are especially known to the farmers, namely, *Tridax procumbens* (40.90%), *Opus* sp. (25.6%) and *Striga hermonthica* (25.36%); the sandy nature of the soil (49.05%) and the bright (26.15%) and white (24.80%) soil are characteristics of infertile soils also commonly used by farmers to classify soil infertility.

Farmers' Criteria for Soil Classification: Basing their judgement on soil colour and texture, abundance of plants, animals as well as other indicators like production yields and the ease with which the soil is worked, Mbe farmers succeed in making out four soil types, classifying them from black soil to gravel soil (Figure 2). Black soils that abound with earthworm and are covered with vegetation like *Terminalia macroptera* are considered the most fertile (51.40% of the responses). These soils have a high water holding capacity. After these, is the sandy-clay (39.00%) that is brighter in colour with humidity that is less than that of the former. Limon (9.04%) and gravel (0.56 %) soils are not appreciated much by farmers because of their low production yields.

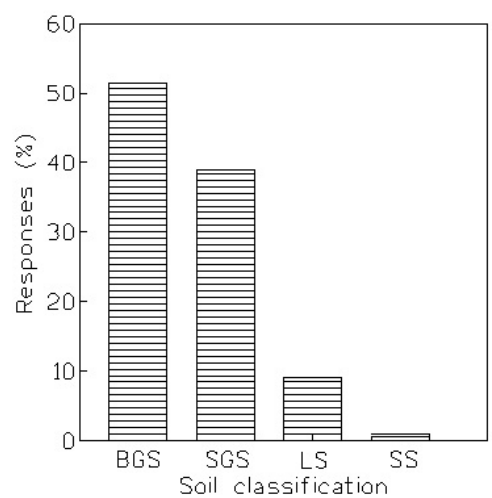

Fig. 2: Mains farmers' classification of soil type. BGS: black grey soil; SGS: sandy grey soil; LS: limonous soil and SS: sandy soil.

Agricultural Practices, "Soil Tiredness" and Their Remedies: To clear and work the land, several techniques are used (Figure 3). Manual labour is by far the most used method (45.91% of total responses)

Table 4: Farmers' indicators of poor soils in the traditional land uses of Mbe region (% of responses).

	Vegetation indicators		physical indicators	
Scientific Name	Family	Response (%)	Soil characteristics	Response (%)
Acacia nilotica	Mimosaceae	5.12	Sandy	49.05
Acacia seyal	Mimosaceae	3.02	Bright colour	26.15
Opus sp.	Poaceae	25.36	White colour	24.80
Striga hermonthica	Scrofulariaceae	40.90		
Tridax procumbens	Asteraceae	25.60		

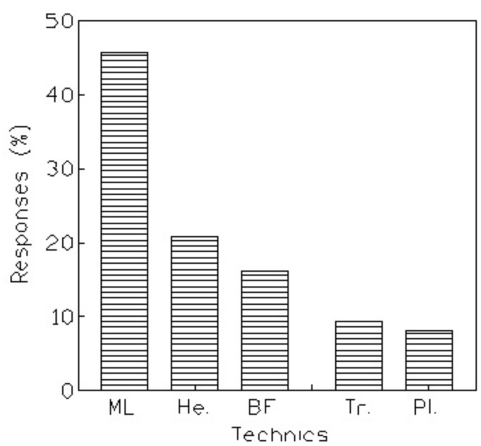

Fig. 3: Mains Farmers' cultivation techniques of Mbe Humid Savannas.
ML: manual labour; He.: herbicides; BF: Bush fires; Tr.: tractors; Pl: plough

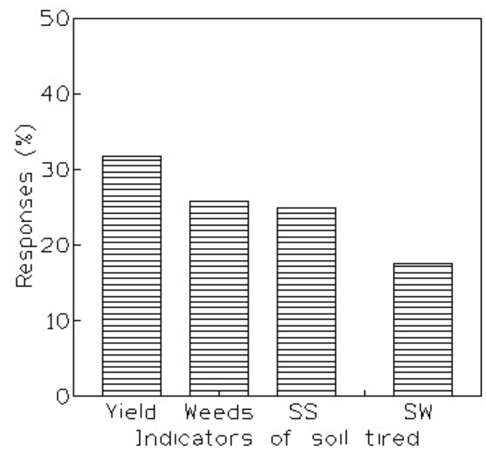

Fig. 4: Mains farmers' indicators of *soil tiredness.* SS: sandy soil and SW: soil work

through the use of the hoe, the cutlass, and the axe. Herbicides are employed (20.00%) while the harnessed tractor (9.42%) and plough (8.00%) are scarcely used. Mostly the family (65.53%) and/or other hired villagers (32.27%) supply labour and manpower is almost never sought from without the village (2.18%).

To the farmers, soil tiredness is reflected most by a reduction in output (more than 31% of the responses), by the appearance of some special kind of weeds in the farms (25.86%) and an increasing sandiness of the soil (Figure 4). Consequently, such poor but cultivated lands demand many more soil-breaking sessions and need large quantities of agricultural inputs. More than half of the Mbe farmers (57%) consider that a farmland becomes tired after 3 to 6 years of continuous cultivation, 22% claim that degradation sets in between 6-10 years, while 21% among them considered that soil tiredness occurs after 10 years of continual cultivation.

As remedy to the low fertility situation indicated generally by progressive reductions in yields, the farmers employ several strategies (Table 5). The principles include the use of organic manure (37.00%), land fallowing (40.50%) and crop rotation (22.5% of responses). Various rotations or successions of cropping are done. According to soil quality and vegetation cover, we grouped in two main types. For vegetation cover of *Terminalia macroptera*, the Mbe farmers first plant yams which needed fertile soil, then corn, or cassava and then either cotton, groundnuts or millet, which grow in less fertile soil. Farmers generally attribute the soil fertility maintenance or improvement to the quality of roots of this plant species. According to farmers such trees have direct effects on soil through root, and indirect effects through shade and regulation of humidity and wind speed. Through shade management, farmers are able to reduce light intensity, regulation temperature, air movement and humidity, which affect the incidence of pests and diseases. Also for the vegetation cover of gramineae, after clearing and burning or for fertile farms by organic inputs, farmers grow a diversity of crops, with different harvesting sequence; fast-growing crops such as groundnut or maize, rapidly use nutrients from the ash. Slow-growing crops such as yam stay longer in the field and make use of nutrients remaining in the soil.

Most of the Mbe farmers practice fallow system. Its duration depends on the extent of exhaustion of the

Table 5: Farmers' strategies of management and different types of fertilizers (% of responses)

Management		Fertilizers	
Types of management	Response (%)	Types of fertilizers	Response (%)
Crops rotation	22.5	Animal manure (cows, ovins, Bats)	46.67
Fallows	40.50	Household waste manure	30.00
Use all type of fertilizers	37.00	Sewage	8.33
		Others techniques	15.00

soil, of the type of crop and the number of farmlands that a farmer possesses. More than half of them (59%) estimated that the fallow period should last between 3 and 5 years. In Wack, farms are split in two parts. Then the farmers work first the land in the west for a numbers of years and then move to the east, leaving the former on fallow, and so on. These farmers judge the return of fertility to the fields left on fallow by the re-coverage of such pieces of land by an abundant vegetation, by the appearance of biological indicators like *Imperata, Andropogon* and the presence of earthworm casts. After this judgement, the fallow lands was cleared and burned of the residues. The residues remaining after burning are piled up and burned again, resulting in accumulation of ash in some areas of the field. Burning supplies nutrients on soil and reduces the Chromolaena and Striga see bank, thus delaying weeding operations and improves soil fertility.

Agricultural inputs (organic) are varied (Table 5), however, animal manure (cows, ovins and bats) (46.67%) was widely used than household waste (30.00%). Yet other techniques (15.00%) are employed to ensure soil fertility. Instead of abandoning tired farmlands to fallow, farmers raise ridges in them, thus bringing to the surface in the process, deep-seated organic matter. Still other farmers clear the farmland at the end of the rainy season (September) so the grass can rot and decompose and the farmland thus cleared will be planted in the beginning of the next rainy season.

Discussion:

Concept of Soil Fertility: Farmers of the Mbe humid savannas are very well aware of the concept of soil fertility. This concept is reflected in local expressions like *hack-ké* and *hack-dii* in Dourou and *teciri bella* in Mboum, *taa bay* in Toupouri, used to designate soil fertility. These expressions which translate “good soil” (*hack-ké and teciri bella*), “black soil” (*hack-dii and taa bay*) and “oily soil” (*hack-koun*) suggest that the concept of fertility to the Mbe farmers refers more to the physical quality and output of soils, inasmuch as fertile soil (*good soil*) is that one that gives high yields. Black soil is the one that is rich in organic matter, derived from the decomposition of litter to give humus, a colloidal substance that fixes the mineral elements of the soil and plays an important role in plant nutrition. Serpantié and Ouattara[10] confirmed the assertion that humus constitutes a good indicator for the components of soil fertility. Besides, by relating soil fertility to oil, the farmer is probably thinking that the soil likely possesses a precious substance that it transfers to the plant for its development.

Similarities exist between the different expressions of the tribes. To the Dourou and Mboum, both indigenous peoples of the Adamawa, fertility designated by *hack-ké* for the former and *teceri bella* for the latter translates as *good soil*. There is also similarity between the appellations of soil fertility in Toupouri - people from the far north, but living in the Mbe region - and in Dourou: namely, *hack-dii* in the first and *taa bay* in the second, both meaning black soil.

Farmers’ Indicators of Soil Fertility and Infertility: When the farmers have to do with hitherto unexploited or secondary vegetation covered farmland, they use a series of bio-physical indicators of soil fertility, composed of plants, animals and soil physical quality to decide on the outcome of their agricultural undertaking. According to their logic, a varied, vigorous and thick rich plant cover, made up of large trees, high herbs coupled with an equally abundant animal life and to which the farmers associate soil colour and structure, abundance of earthworms and their casts as well as the presence of termites all constitute signs of vitality and fertility of the soil. Likewise, poor soils are also characterised by a biological complex, which is also poor. Some dispersed herbaceous plants dominate the vegetation of these soils, which are very much of gravel and clear in colour. Such soil types do not inspire the farmers for agricultural purposes. These various biological (flora and fauna) and physical indicators used by farmers of Mbe to differentiate empirically fertile from infertile soils have been mentioned in the works of Donfack[3] in Maroua and Pabame[11] at Ngong, all located in the dry (or Sudan) savannas of the North of Cameroon. These various indicators have also been reported in the works of Kanmegne[12] in the humid tropical forest of South Cameroon, and those of Soumana[13] and Quansah *et al.*[14] in the Sudan savannas of West Africa.

Meanwhile, the quality of taxons, their diversity, and indicator importance vary according to the regions and agro-ecological zones. With respect to the plant families used as indicators of soil fertility, our findings reveal that the *poaceae* take the first place (39% of the total responses), followed by the *mimosaceae* (21.73%) and *combrataceae* (17.00%). Likewise, this variation in indicator importance with regards to ecological zones is also noticeable with plant species. For instance, *Imperata cylindrica, Terminalia macroptera, Pennisetum purpureum and Rottbollina cochinchinensis* are most commonly used as soil fertility indicator. On the other hand, in the Sudan savannas of North Cameroon, it is mostly the *Acacia albida* (16.00%) and *Vitellaria paradoxa* (15.00%) that are mostly cited as fertile soil indicators[11]. Besides, Quansah *et al.*[14] have shown that in the Ghanaian savannas, the vegetation constitutes more the farmers' indicators than soil quality (64.00% versus 24.00% of responses), while in the humid forest zone, it is instead the soil quality that is currently used as soil fertility indicator (91.00 versus 1.00%). The bio-geographical context and density of the vegetation cover explains this difference[14].

Findings of the research carried out by Lavabre[15] show that plant species belonging to the *Commelina* kind are classified among those that indicate *soil tiredness*. Dugué *et al.*[16] assert that *Commelina* like *Striga* appear on soil that has been cultivated continuously for at least eight years. On the contrary, Belinga[17], in a study carried out in the Mafa-Kilda land (North Cameroon) noted that *Commelina* is indicative rather of fertile soils. Bourgeois and Merlier[18] who found that *Commelina* grows on sandy alluvial and ferrugineous tropical, well-structured soils, but grows with difficulty on degraded ferrugineous soils support their claim. These differences between the two study groups give the impression that soil quality counts for much in the adaptation of *Commelina* to its environment. The presence of the *Acacia seyal*, even though a leguminous plant known for its nitrogen retaining capacity, is cited here as an indicator of poor soil. This confirms the findings of Breman and Kessler[19], who reported that *Acacia seyal's* nitrogen supply is negligible.

Briefly, the abundance and diversity of indicators cited is illustrative of the fact that the farmers of this region, because of their long experience in the farming systems have indicators that they use in assessing their immediate environment. They possess an established perception and empirical knowledge of soil fertility indicators. Moreover, it is because of their mastery of these indicators that these farmers have come to notice with a lot of anxiety, the deterioration of their lands and landscape[3]. It is also for this same reason that Soumana[13] thinks that the farmer should be recognised as a *meticulous* observer of his environment. His holistic vision of soil fertility and soil itself, has given rise to a farmer perception system with its plant, animal, and physical components, all intimately interwoven. The use of these indicators is crucial particularly to these farmers deprived of any other means[13]. By determining the inter-relations that exists between the phyto-faunic complex and their influence on soil fertility, the Mbe farmer shows proof of the fact that he can establish a close link between the soil, plants and animals. From these indicators he can also, empirically determine the type of crop to grow. For instance, a soil that is abundantly covered by cob (*Isoberlinia doka*), associated with the presence of earthworm casts is to the farmer, a soil that is good for the cultivation of millet and other cereals. Practically all the farmers questioned (99.00%) agreed that a soil covered by *Terminalia macroptera is convenient* for yam cultivation. The roots of this specie, according to some farmers would seem to have a positive effect on soil fertility. For cassava, a slightly dark and gravel soil would be more propitious and particularly to the late or traditional variety called *gataran* in Dourou. Corn and groundnut generally speaking can follow a vegetation cover of diee (*Pennisetum purpureum*).

Soil Tiredness and Soil Fertility Management: In the Mbe region, it is difficult to hear a farmer talk of the death of farmlands unlike in Mali and Ghana where it is a household complaint [13,14]. The practice of long duration fallowing has practically disappeared from the region[2], moreover, there remains very few of the older farmers who master this technique (only 16% of persons of more than 60 years were sampled). On the other hand, most of the Mbe farmers mention the *tiredness* of farmlands which is manifested by a regular drop in yields, the absence of an abundant vegetation cover, appearance of particular kinds of weeds, an increase in labour effort shown in the multiplication of soil softening sessions and the need for substantial amounts of agricultural inputs. Those that indicate that the soil is increasingly becoming tired replace plants indicative of soil fertility. These findings do not seem to deviate from those found in available literature on the subject[13]. The notion or concept of *soil tiredness* is not limited to the African farmer, let alone those of Mbe. The expression appeared in France in about the 1980s, in the discourse of farmers as they expressed themselves on heterogeneous phenomena[20] that are certainly different from those that affect the soils in Cameroon. However, soil tiredness is a reflection of only various degrees of soil usage.

Declining soil fertility is perceived by most Mbe farmers as a major constraint to agricultural production[14,12] and this study. There are diverse ways by which soil fertility is maintained or improved upon; the principles include firstly the land fallowing (40.50%), secondly, the use of agricultural inputs (37.00% of responses, among which are animal manure and household: 76.67%), and lastly, crop rotation (22.5%). As other parts of Africa, fallow is the most common traditional farming practice in Cameroon[2,12,21]. The tendency is to abandon the practice of long fallow periods. At present, fallow duration is limited to between 3-5 years, like was found in other studies[2,3]. Since the practice of short fallow periods can no longer cause the reconstitution of fertility, trials of improved fallowing are under study, with the introduction of trees[22] or folder leguminous plants like *Sesbania sesban* in farms[23]. The planted fallows are reported to accumulate high biomass, and regenerate soil properties in a shorter time than natural fallows. These systems are not yet widespread. Some farmers leave after clearing some plant species like the *Terminalia macroptera* to grow in the farms.

Even though they are very aware of the potentials of natural fertilisers in restoring soil fertility, Mbe farmers give several reasons to justify the low use quantity of this type of fertiliser. The use of animal waste is the likely cause of the growth of much grass in the farms. The insufficiency (low availability) and difficulty in collecting is a probable cause of the little interest that Mbe farmers show with respect to the use of this type of fertiliser. The fact was also reported by Quansah *et al.*[14] concerning Ghanaian farmers and by Boutrais[24] with regards to Dourou farmers of the Adamawa, as according to these authors, the number of cattle was small to be able to supply enough manure. Passarges[25] justify this small cattle number (traditional rearing technique) in Dourou land by the presence of glossina. Animal rearing is limited to poultry. A study carried out in the region of Niamey revealed that the farmers attach more importance to the droppings of small ruminants than to those of bovine. This is explained by the fact that the nitrogen and phosphorus contents are higher in the latter[26]. These high content rates are likely the cause of plant burns (withering) caused by this kind of manure, mentioned by Mbe farmers.

Household wastes and sewage are generally used in small farm areas (home gardens), because they are not available in large quantities and because their spreading is more difficult. Animal manure would be very useful, since according to Boutrais[24], if it is well handled, it can manage two contradicting phenomena: the maintenance of soil fertility and allay the risk of weed choking of crops. According to Landais *et al.*[27], raising animal would constitute a good alternative for the reconstitution of soil fertility through long fallow periods in extensive systems, in as much as animals can valorise crop residue in situ after harvest by enabling the rapid transformation of the latter into fertilising elements.

About 87% of farmers interviewed added chemical-fertiliser in their farms for some crops like maize. The high use percentage of this fertilizes in the region is justified by its immediate availability, since the advent in this region of the Cotton Company (SODECOTON), which supplies the farmers with chemical inputs in the form of credit payable after harvest. These inputs are supplied for the sole purpose of treating the cotton plant and fertilising the cotton farm. Unfortunately, the farmers use them abnormally on some the other crops. This would led to degradation of environment (soil pollution, soil organisms reduction,..). Fortunately, the drastic drop in the purchasing power of the farmers caused by the failure of modern farming systems, the use of chemical fertilisers has decreased remarkably in the last four years. In addition, the traditional cultivation system is being improved upon thanks to the presence of drive forces of region like PADI, *Mutual-help-groups, cotton-production-groups,* and the Women for *Christ group* which help farmers to abandon chemical fertilisers uses for collecting and distribution of animal dejections and kitchen residues.

The indigenous knowledge of farmers for composting refuse and residues, decomposing of crop residues or litter collecting was very low. But in the areas with high population density and intensive agriculture, composting and recycling of household residues are rooted[28].

Conclusion: Mbe farmers have a fairly good knowledge of the concept of soil fertility according to their own indigenous system, based on experience and the transmission of knowledge from generation to generation. They make use of indicators of biological and physical which enable them to evaluate the soil fertility. They also make use of diversity of strategies to maintain or improve upon the fertility of their farmlands in the struggle to increase agricultural production. Many of these fit well in local conditions, and can lead to conservation and regeneration of the natural resource base, but not all are effective. Therefore, modifications, adaptations or introduction new techniques are necessary[29]. Such modifications should take into consideration farmers' rational and knowledge[5,29]. This should be based on a through knowledge on how farmers use household and characteristics to make adoption decisions.

ACKNOWLEDGMENTS

We thank all the farmer collaborators in carrying out this survey. The research was partly sponsored by the University of Ngaoundere through of GPRU, by the International Foundation for Science (IFS), Stockholm, Sweden as well as the United Nation University (UNU), Tokyo, Japan, through a made to Dr IBRAHIMA Adamou.

REFERENCES

1. Mapongmetsem, P.M., 2005. Phénologie et apports au sol des substances biogènes par la litière de quelques fruitiers sauvages des savanes soudano-guinéennes. Thèse de Doctorat d'Etat, Universite de Yaounde I., pp: 242.
2. Anonymous, 1994. Diagnostic général de la situation de l'environnement dans la province de l'Adamaoua. Elaboration du plan national de gestion de l'environnement au Cameroun. Document de base, MINEF, GTZ, pp: 143.
3. Donfack, P., 1998. Végétation des jachères du Nord-Cameroun: typologie, diversité, dynamique et production. Thèse de Doctorat d'Etat, Université de Yaoundé I, pp: 270.
4. Gitihnji, M.K., 2003. La déception du groupe ACP à Cancun. Le courrier, la magazine de la coopération au Développement ACP-EU, n° 200: 10-11.
5. Buttner, U. and S. Hauser, 2003. Farmer's nutrient management practices in indigenous cropping systems in southern Cameroon. Agriculture, Ecosystems and Environment, 100: 103-110.
6. Suchel, J.B., 1971. La répartition des pluies et régimes pluviométriques au Cameroun. Centre de Recherches Africaines, Université fédérale du Cameroun.
7. Brabant, P. and F.X. Humbel, 1974. Notice explicative de la carte pédologique de Poli, n° 51, Carte au 1/50000e, Yaoundé.
8. Letouzey, R., 1968. Etude phytogeographique du Cameroun. Le chevalier (Ed.), Paris, pp: 511.
9. Divisional Delegation of Agriculture, 2002. Rapport bilan agricole 2001/2002, Mbe, pp: 96.
10. Serpantié, G. and B. Ouattara, 2001. Fertilité et jachère en Afrique de l'Ouest. In: Floret Ch. and Pontanier R. (Eds) La jachère en Afrique tropicale, ICRA, Dakar Sénégal, pp: 21-83.
11. Pabame, P., 2002. Indicateurs et gestion paysans de la fertilité des sols dans les régions de Mbé, Adamaoua - Cameroun. Mémoire de Maîtrise, Fac. Sci., Université de Ngaoundéré, pp: 49.
12. Kanmegne, J., 2004. Slash and burn agriculture in the humid forest zone of southern Cameroon: Soil quality dynamics, improved fallow management and farmers' perception. PhD thesis Wageningen University and Research Centre, The Netherlands, pp: 185.
13. Soumana, I., 2000. Indicateurs biologiques paysans de la fertilité du sol au Niger. In: Floret Ch. and Pontanier R. (Eds) La jachère en Afrique tropicale, John Libbey, Paris, pp: 103-110.
14. Quansah, C.P. Drechsel, B.B. Yirenkyi and S. Asante-Mensah, 2001. Farmers' perceptions and management of soil organic matter - a case study from West Africa. Nutrient Cycling in Agroecosystems, 61: 205-213.
15. Lavabre, E.M., 1988. Le désherbage des cultures tropicales. Maisonneuve et Larose (Ed.), Paris, pp: 127.
16. Dugué, P., J. Kouladji and C. Moussa, 1997. Diversité et zonage des situations agricoles et pastorales de la zone cotonnière du Nord-Cameroun. IRA/IRZ, Projet Garoua II, pp: 84.
17. Belinga, G., 2000. Dégradation des sols cultivés au Nord-Cameroun, inventaire et identification des indicateurs et techniques endogènes de lutte utilisée par les paysans: cas du territoire de Mafa-Kilda, Mémoire FASA, Dschang, pp: 320.
18. Bourgeois, T. and H. Merlier, 1995. Adventrop, les adventices d'Afrique soudano-sahéliennes. CIRAD-CA (Ed.), Montpellier, pp: 640.
19. Breman, H. and J.J. Kessler, 1995. Woody plants in agro-systems of semi-arid regions, with and emphasis on the Sahelian countries, advanced series. Agricultural sciences, Springer verlag, Berlin, pp: 23-340.
20. Veauvy, Chr., 1991. L'usure des sols et ses représentations sociales. Le cas de la Province contemporaine. Savoirs paysans et Développement, Paris, Kartala, Orstom, pp. 111-132.
21. Anonymous, 1999. Pratique et durée des jachères dans les champs de cultures vivrières. Sécheresse, 10(2): 90-91.
22. Harmand, J.M., 1997. Rôle des espèces ligneuses à croissance rapide dans le fonctionnement biogéochimique de la jachère. Effet sur la restauration de la fertilité des sols ferrugineux tropicaux, cas du Bassin de la Bénoué au Nord - Cameroun. Montpellier, Cirad, Département Forêt, pp: 213. +annexes.
23. Mapongmetsem, P.M. and A. Ibrahima, 1999. Sesbania parchycarpa et jachère améliorée en zone soudano-guinéenne (Cameroun). In: Floret Ch. and Pontanier R. (Eds) La jachère en Afrique tropicale, ICRA, Dakar Sénégal, pp: 42-45.
24. Boutrais, J., 1998. L'agro-élevage des Foulbé de Ngaoundéré (Adamaoua camerounais). Les évolutions des relations entre l'agriculture et

l'élevage. In: Actes de l'Atelier CIRAD, 5-6 mai, 1998, Montpellier, pp: 107-120.

25. Passarges, S., 1984. Adamawa. Rapport de l'expédition du comité allemand pour le Cameroun au cours des années 1893/1894. Berlin, Traduit de l'allemand par Eldrige M., pp: 167.
26. Williams, T.O., J.M. Powell and S. Fernandez-Rivera, 1995. Manure utilisation drought cycles and herd dynamics in the Sahel. Implications for cropland. In: Powell J.M., Fernandez - Rivera S., Williams T.O.and Renard C. (Eds) Livestock and sustainable nutrient cycling in mixed farming systems of sub-Saharan Africa. Volume II: technical Papers. Proceedings of an International Conference held in Addis-Abeba, Ethiopia, 22-26 November 1993. ILCA, Addis-Abeba, pp: 393-409.
27. Landais, E.P. Lhoste and H. Guerin, 1991. Système d'élevage et transfert de fertilité. In: Ministère de la coopération et du développement (Ed.) Savane d'Afrique, terres fertiles, comment produire plus et de façon durable en zone d'Afrique au sud du Sahara, Paris, France.
28. Ceccolini, L., 2002. The home garden of Soqotra island, Yemen: an exemple of agroforestry approach to multiple land-use in an isolated location. Agroforestry Systems, 56: 107-115.
29. Altieri, M.A, 2002. Agroecology: the science of natural resource management for poor farmers in marginal environments. Agriculture, Ecosystems and Environment, 93: 1-24.