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Soil conservation practices in three watersheds of Benin: Farmers' cropping systems characterization

Félix Alladassi Kouelo[1]*, Pascal Houngnandan[1], Houinsou Dedehouanou[2], Rigobert Tossou[2], Daouda Orou Bello[3], Joël Kossobakan Afiolorom Bekou[1] and Anselme Yenakpon Tchetangni[4]

[1]Laboratoire de Microbiologie des Sols et d'Ecologie Microbienne, Faculté des Sciences Agronomiques, Université d'Abomey-Calavi (LMSEM/FSA/UAC), Benin.
[2]Département d'Economie, de Sociologie, d'Anthropologie et de Communication, Faculté des Sciences Agronomiques, Université d'Abomey-Calavi (DESAC/FSA/UAC), Benin.
[3]Unité de Recherche Gestion Intégrée des Sols et des Cultures, Laboratoire des Sciences du Sol, Faculté des Sciences Agronomiques, Université d'Abomey-Calavi, Benin.
[4]Secteur Communal pour le Développement Agricole de Djidja, Centre d'Action pour le Développement Rural Zou/Collines, Benin.

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This document addresses the farming practices and their characteristics on three watersheds in southern Benin. These watersheds are located in the villages of Govié, in Allada district, Lokogba in Aplahoué district and Linsinlin in Djidja district. Simple random sampling is used to investigate 417 farm households at the rate of 139 per village. Focus groups are conducted with resource persons and individual interviews according to a survey tool. The observation unit of the survey is the head of the farm household. In the villages of Lokogba and Linsinlin, farm households practice slash and burn agriculture in contrast to those of the village of Govié where residues are not burned. Soil conservation practices (direct sowing, minimum tillage) are made in the village of Lokogba while tillage is widely practiced in the other villages. In the village of Govié, some households use mulch and mineral fertilizers, but the rate is low. Organic fertilizers are used by 40.2% of farmers in Lokogba village. Crop rotation and fallow are still widely practiced in this village by 85.6 and 84.6% of the surveyed households respectively. In other villages, these practices are absent or present at very low levels showing their high level of agricultural intensification. Weeding is the main preventive measures used by farmers in village of Govié (38.8%), Lokogba (93.8%) and Linsinlin (23.2%). Chemical pests control is used by all farmers of village of Linsinlin and Lokogba. The farming practices are significantly specific to the surveyed villages. Soil conservation practices are more observed at Govié than Lokogba. In the village of Linsinlin, these practices are almost absent.

Key words: Soil conservation, farming practices, cropping systems, watersheds, Benin.

INTRODUCTION

Soil and water are basic, vital and essential resources for sustainable agriculture. Sustainability implies here utilizing these resources in ways that ensure little or no damage whilst guaranteeing their continuous usage

(Ahaneku, 2010). Land degradation was a significant global issue during the 20th century and remains of high importance in the 21st century as it affects the environment, agronomic productivity, food security, and quality of life (Eswaran et al., 2001). Soil degradation processes include the loss of topsoil by the action of water or wind, chemical deterioration such as nutrient depletion, physical degradation such as compaction, and biological deterioration of natural resources including the reduction of soil biodiversity (Lal, 2001).

There is also human - induced soil degradation through overgrazing, deforestation and inappropriate agricultural activities. This also poses a serious threat to land productivity. The abandonment of existing degraded pastures and cropland, the move to new land for grazing and crop production are responses to the decline in soil fertility. Unless there are investments in soil conservation, the process will be repeated in a vicious circle overgrazing and continuous cropping causing land degradation and then the search for new pastures and cropland (Barbier, 2000).

African farmers operate in different environments, some having enough resources, others operating in resource constrained environment. Farming system typologies are dictated by climate, production goals and culture with a farming system being described as a unit consisting of a human group (usually a household) and the resources it manages in its environment, involving the direct production of plant and/or animal products (Scherr, 1999). A farming system describes what is currently being done by a group of farmers operating under certain common conditions. The system focuses on farm-household and rural community systems and their interactions with physical, socio-cultural and political environments (Kalisa, 2007). Each individual farm has its own specific characteristics, which arise from variations in resource endowments and family circumstances. The household, its resources, and the resource flows and interactions at this individual farm level are together referred to as a farm system.

Though agriculture in Benin occupies 75% of the population (MAEP, 2010), it is not articulated yet around the techniques and the methods (the most modern) for fully satisfying the needs of the population. Its development as well as the level of production performances as the conservation, the processing and the commercialization of agricultural products are limited (SCRP, 2007).

Several strategies of water and soils conservation (WSC) were developed and spread in Benin by development projects since 1960. Avoidance of soil loss by improved management and the conservation of natural resources is therefore important to maintain the functions of the soil and contribute to food security today and for future generations (Ehui and Pender, 2005). Research on soil conservation has been conducted for many years in Sub-Saharan Africa (Ehrenstein, 2002) and in Benin (Saidou, 2005). Farmers have been slow in adopting appropriate soil conservation measures, which they consider to be high labor and capital requiring during construction and maintenance and also as a waste of land (Khisa et al., 2002).

Access to land is a problem, especially in the south, where the population density is very high. Farm sizes are on average 1.7 ha for a family of 6 to 7 persons, while off-farm activities remain rare. Sloping lands, such as watersheds, are intensively cultivated over the plateau land (MAEP, 2007). But they are more susceptible to degradation and thus could no longer feed farmers. This population of watersheds, out of food insecurity more and more aggravating, must produce more with their limited resources. Accordingly, farming practices need to be more productive and sustainable. It is necessary to make an inventory of agricultural practices on watersheds to identify needed improvements for adequate and sustainable production.

This study aims at characterizing agricultural practices at three watersheds of southern regions of Benin.

MATERIAL AND METHODS

Study area and villages' selection

This study covers three watersheds in southern regions of Benin. These watersheds are characterized by a ferralitic soil called "Terre de barre". This is a very sensitive soil to degradation and mainly to erosion because they are sloped (slope at least 5%). The main activity in these watersheds is agriculture with a very high population density. Their soil is under severe land pressure. They watersheds are located in the district of Allada (watershed of Govié village), the district of Aplahoue (watershed of Lokogba village) and the district of Djidja (watershed of Linsinlin village). Allada district is located between longitude 2° 9 '35' 'East and latitude 6° 39'52 "North. It covers 381 km^2 with a population density of 240.9 inhabitants per squared kilometer. Aplahoue district is located between longitude 1° 40 '25 "East and latitude 6° 56'32 " North. It covers 572 km^2 with a population density of 240.5 inhabitants per squared kilometer. Djidja district is located between longitude 1° 56 '8 "East and latitude 7° 20'46 " North. It covers 2,184 km^2 with a population density of 38.7 inhabitants per squared kilometer. Figure 1 shows the location of the study sites. Allada and Aplahoue districts are characterized by a sub-equatorial climate with two (02) rainy seasons and two (02) dry seasons. Annual rainfall ranges from 900 to 1100 mm. But, Djidja district enjoys a climate of sub-equatorial tending to Sudano-Guinean in the northern parts.

Selection of the research units

The research units are the households represented by their heads.

*Corresponding author. E-mail: lijalem.tsegay@gmail.com.

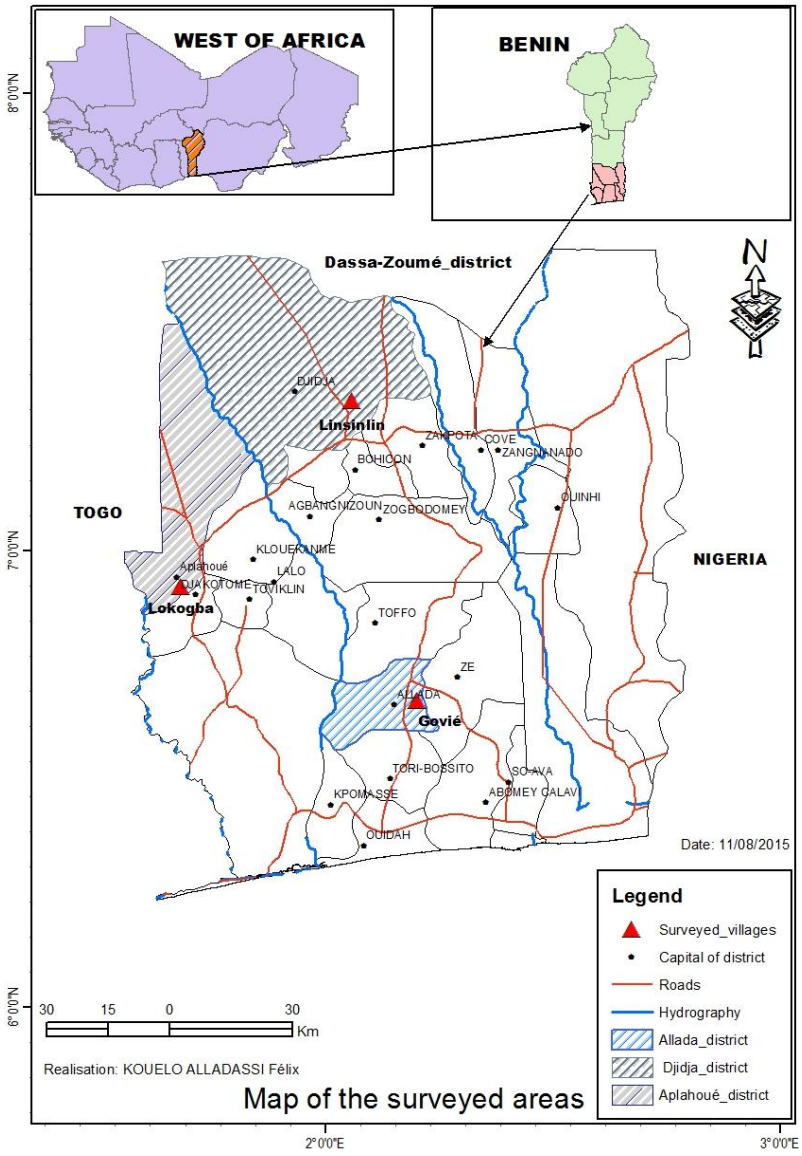

Figure 1. Map of the surveyed areas.

They are chosen randomly in order to be a representative sample of the population. According to Dagnelie (1998), the sample size required can be calculated by applying the following formula:

$N = [(U_{1-\alpha/2})^2 \times p(1-p)]/d^2$

with n≥ 50 and p≥ 1/10 of population, N = sample size required per village of study; $U_{1-\alpha/2}$ = confidence level of 95% (typical value of 1.96); p = proportion known or suspected in the parent population; d = margin of error of 5% (typical value of 0.05). To calculate the sample size, we take p = 0.1; thus n = 139. This is the minimum possible size per site for this survey. For the three watersheds' villages, 417 farm households are surveyed.

Data, collection and tools of analysis

The data used consist of variables such as socio-economic and demographic characteristics and farming practices (clearing, tillage, mulching, fertilization, crop rotation, pest management and fallow). Data are analyzed using descriptive statistics and frequencies in SPSS version 16. The Chi square test is conducted to statistically verify whether there is a dependency between agricultural practices and watersheds. This test informs us about the specificity or not of farming practices in relation to watersheds studied.

RESULTS

Profiles (Characteristics) of the sampled households

On Tables 1 to 3, we present the profiles of the sampled farmers. The main characteristics of households considered in the study include among others the socioeconomic, education and demographic characteristics. Household heads are predominantly

Table 1. Social characteristics of farmers in the three surveyed villages.

Variables	Modalities	Frequency (%)		
		Govié	Lokogba	Linsinlin
Gender	Male	122 (87.8)	108 (77.7)	103 (74.1)
	Female	17 (12.2)	31 (22.3)	36 (25.9)
Religion	Animist	62 (44.6)	63 (45.3)	97 (69.8)
	Christian	75 (54.0)	76 (54.7)	42 (30.2)
	Muslim	2 (1.4)	-	-
Marital status	Single	20 (14.4)	9 (5.5)	11 (7.9)
	Married	110 (79.1)	113 (81.3)	126 (90.6)
	Divorced	3 (2.2)	3 (2.2)	2 (1.4)
	Widowed	6 (4.3)	14 (10.1)	-
Household	Native	129 (92.8)	139 (100.0)	123 (88.5)
	Immigrant	10 (7.2)	-	13 (9.4)
	No answers	-	-	3 (2.2)
Land tenure status	Heritage	86 (36.7)	130 (93.5)	117 (83.0)
	Donation	9 (3.8)	8 (5.8)	16 (11.4)
	Renting	53 (22.6)	-	2 (1.4)
	Purchase	50 (21.3)	1 (0.7)	3 (2.1)
	Share cropping	36 (15.4)	-	-
	No answers	-	-	3 (2.1)

Source: Field Survey, 2013.

Table 2. Demographic characteristics of the surveyed farmers.

Variables	Modalities	Frequency (%)		
		Govié	Lokogba	Linsinlin
Age	<30 years	14 (10.1)	26 (18.7)	34 (24.4)
	30 - 40	44 (31.6)	56 (40.3)	55 (39.6)
	40 - 50	41 (29.5)	39 (28.1)	30 (21.6)
	50 - 60	26 (18.7)	18 (12.9)	20 (14.4)
	>60 years	14 (10.1)	-	-
	Mean	44.5 ± 9.4	39.3 ± 8.7	38.6 ± 9.8
	Minimum	20	22	24
	Maximum	75	58	60
Household size	<5	-	1 (0.7)	24 (17.3)
	5 - 10	75 (54.0)	102 (73.4)	91 (65.5)
	10 - 15	63 (45.3)	36 (25.9)	21 (15.1)
	>15	1 (0.7)	-	3 (2.1)
	Mean	09 ± 2	8 ± 2	8 ± 2
	Minimum	5	4	3
	Maximum	15	14	16

Source: Field Survey, 2013.

male, respectively 87.80, 77.70 and 74.10% in the villages of Govié, Lokogba and Linsinlin. Women heads of household are recently widows or women whose husbands have travelled. While they are mostly of

Table 3. Education characteristics and agricultural extension rate.

Variables	Modalities	Frequency (%)		
		Govié	Lokogba	Linsinlin
Level of education	Illiterate	66 (47.5)	89 (64.0)	118 (84.9)
	Primary level	61 (43.9)	40 (28.8)	17 (12.2)
	Secondary level	12 (8.6)	10 (7.2)	4 (2.9)
Literacy	Not Alphabetized	72 (51.8)	139 (100.0)	117 (84.2)
	Alphabetized	67 (48.2)	-	22 (15.8)
Farmer organization	Not member	121 (87.1)	135 (97.1)	58 (41.7)
	Member	18 (12.9)	4 (2.9)	81 (58.3)
Agricultural extension	Not mentored	96 (69.1)	96 (69.1)	53 (38.1)
	CARDER	41 (29.5)	43 (30.9)	80 (58.3)
	NGO	2 (1.4)	-	5 (3.6)

Source: Field Survey, 2013.

traditional religion (Animist) in the village of Linsinlin (97% of farmers), those from the villages of Govié and Lokogba practice the Christian religions in majority (54 and 54.7% respectively). Most household heads are married. The immigration rate is very low or zero in the surveyed villages. The primary mode of land tenure is heritage (61.87% in the village of Govié, 93.5% in the village of Lokogba and 84.17% in the village of Linsinlin). Age is an important factor, which affect the potential employment and mobility status of respondents. The average age of household heads surveyed is 45 years in Govié, 40 years in Lokogba and 39 years in Linsinlin. The mean size of households is 11 persons in the village of Govié and 8 persons in the villages of Lokogba and Linsinlin (Table 2). In the three villages, household heads are older and adults at majority (30 to 50 years). In the villages of Lokogba and Linsinlin, most farmers are not educated (illiterate). In the first village, nearly 29% of farmers have the primary level unlike farmers of the second village (12%). These results are explained by the fact that the village of Lokogba in Aplahoue district is very close to the urban center of Azovè (2 km) while the village of Linsinlin whose nearest urban center, Bohicon, is approximately 15 km away. In the village of Govié, the level of education is high (44%) for the primary level and 9% for the secondary level. This is because this village in Allada district is closer to its urban center, Allada, and also nearer to the economic capital (Cotonou) of Benin than the other two villages. In the villages of Govié and Lokogba, most farmers do not belong to farmer's organization unlike Linsinlin village where 58% of farmers are members of farmer's organization (Table 3). Most of farmers' organizations are forums where farmers can access useful information and share experiences. The main agricultural extension structure in the three surveyed villages is the Regional Agricultural Centre for Rural Development (CARDER). The rate of agricultural extension services is low in the villages of Govié and Lokogba, but high in the village of Linsinlin (58%). Outside the CARDER, some NGOs are also involved in the technical support to farmers in the villages of Govié and Linsinlin, but at a very low rate.

Farming systems practiced in surveyed villages

Soil preparation practices

Different soil preparation practices are significantly specific to watersheds studied, clearing and tillage type at the 1%. The direction of the ridges is also statistically specific, but at the 10% level at the watersheds where farmers practice ridging (Table 4). In the village of Govié, three clearing practices are observed: the clearing without burning (50.2% of farmers) and clearing with incorporation of residues (12.4%) are soil conservation practices. Clearing and burning, a soil degrading practice, are observed in the fields of 37.3% famers. In the village of Lokogba, two main clearing practices are observed: A soil degrading practice (clearing and burning) is observed in the fields of 54.4% farmers and a soil conservation practices (clearing with incorporation of residues) is observed in the fields of 43% farmers. But, in the village of Linsinlin, most farmers practice slash and burn clearing (91.4%) and thus contribute to soil degradation. Conventional tillage (a soil degrading practice) is the main type of tillage practiced in the villages of Govié (63.5%) and Linsinlin (81%), while in the village of Lokogba, the main type of tillage is a soil conservation practice (minimum tillage by 52.5% of farmers). Direct sowing (recommended soil conservation practice) is observed in Govié and Lokogba villages only. In villages where conventional tillage is practiced, ridges are oriented in different directions. In the village of Govié, the

Table 4. Soil preparation activities.

Variables	Modalities	Frequency (%)			Total	Chi-square	Probability
		Govié	Lokogba	Linsinlin		χ^2	α<0.05
Clearing	LCWB	117 (50.2)	4 (2.7)	9 (6.5)	130 (25.0)	226	0.000
	LCAB	87 (37.3)	81 (54.4)	127 (91.4)	295 (56.6)		
	LCARI	29 (12.4)	64 (43.0)	3 (2.2)	96 (18.4)		
Tillage type	NT	46 (22.1)	66 (47.5)	-	112 (22.7)	311.1	0.000
	MT	4 (1.9)	73 (52.5)	28 (19.0)	105 (21.3)		
	CT	132 (63.5)	-	120 (81.0)	251 (50.8)		
	Tillage	26 (12.5)	-	-	26 (5.3)		
Ridges direction	Parallel	53 (37.3)	-	52 (37.1)	105 (37.2)	5.478	0.065
	Cross slope	58 (40.9)	-	42 (30.0)	100 (35.5)		
	WCD	31 (21.8)	-	46 (32.9)	77 (27.3)		

Source: Field Survey, 2013. LCWB = Land clearing without burning; LCAB = Land clearing and burning; LCARI = Land clearing and residues incorporation; NT = No tillage; MT = Minimum tillage; CT = Conventional tillage; Parallel = Parallel to the slope; Perpendicular = Perpendicular to the slope; WCD = without clear direction.

Table 5. Fertilization practices.

Variables	Modalities	Frequency (%)			Total	Chi-Square	Probability
		Govié	Lokogba	Linsinlin		χ^2	α<0.05
Fertilizers	No	123 (87.2)	3 (1.5)	26 (18.6)	152 (31.3)	378.9	0.000
	Mineral	16 (11.3)	119 (58.3)	113 (80.7)	248 (51.1)		
	Organic	2 (1.4)	82 (40.2)	1 (0.7)	85 (17.5)		
Application	Open seed-holes	3 (15.0)	4 (3.6)	32 (23.7)	39 (14.7)	162.98	<0.0001
	On soil	5 (25.0)	98 (88.3)	14 (10.4)	117 (44.0)		
	Closed seed-holes	10 (50.0)	9 (8.1)	87 (64.4)	106 (39.8)		
	Streak	2 (10.0)	-	2 (1.5)	4 (1.5)		

Source: Field Survey, 2013.

ridges are oriented parallel to the slope by 37.3% of farmers and perpendicular to the slope by 40.8% of farmers. But, 21.8% of farmers do not give specific direction to the ridges. In the village of Linsinlin, 37.1% of farmers do orient ridges parallel to the slope and 30% across the slope. Ridges have no clear direction for 32.9% of farmers. At the clearing, there are more soil conservation practices in Govié village than in the two others. At the tillage, practices are more preservative to soil in Lokogba but more degrading to soils in Govié and Linsinlin.

Fertilization practices

Family farms of surveyed villages use fertilizers to increase the productivity of their crops. In the villages of Govié and Linsinlin, none of the surveyed farmers does use organic fertilizers. The fertilization practices in these villages are completely soil degrading practices (Mining agriculture in Govié: 87.2% of farmers do not use any fertilizers while mineral fertilization is practiced by 80.7% of farmers in Linsinlin village). Farmers in Lokogba village use two main practices in fertilization: mineral fertilization (a soil degrading practice) is used by nearly 58.3% of farmers and organic fertilization (soil conservation practice) is used by 40.2% of farmers. NPK and Urea are the mineral fertilizers used by farmers. Household garbage and animal wastes are organic fertilizers used by farmers. There is a very highly significant dependence between fertilization practices and villages of the studied watersheds (χ^2 = 378.9; p = 0.000). So, fertilization is a practice that significantly discriminates the surveyed sites.

The modes of application of mineral and organic fertilizers by farmers in these villages are: Opened seed-holes, closed seed-holes, on soil and in streak (Table 5). Among these modes, the closed seed-holes' ones are the

Table 6. Crop management practices.

Variables	Modalities	Frequency (%)			Total	Chi-square	Probability
		Govié	Lokogba	Linsinlin		χ^2	α<0.05
Crop rotation	No rotation	20 (14.4)	139 (100.0)	108 (77.7)	267 (64.0)	112.0	0.000
	Rotation	119 (85.6)	-	31 (22.3)	150 (36.0)		
Fallow	No fallow	16 (11.2)	139 (100.0)	71 (80.7)	226 (61.1)	112.1	0.000
	Fallow 1	121 (84.6)	-	16 (18.2)	137 (37.0)		
	Fallow 2	6 (4.2)	-	1 (1.1)	7 (1.9)		
Mulching	No mulching	113 (81.3)	139 (100.0)	139 (100.0)	391 (93.8)	55.46	0.000
	Mulching	26 (18.7)	-	-	26 (6.2)		

Source: Field Survey, 2013. Fallow 1 = 1 to 2 years; Fallow2 = 2 to 5 years.

most widely practiced by farmers from the villages of Govié (60%) and Linsinlin (73%). Farmers in the village of Lokogba (88%) rather apply fertilizers on soil (especially for organic fertilizers). The last practice is not a soil degrading mode.

Crop management practices

Crop rotation, fallow and mulching (soil conservation practices) are crop management practices of farmers in the villages of Govié and Linsinlin. Crop rotation is widely practiced in Govié (85.6% of farmers), but poorly practiced in Linsinlin (22.3%). In the village of Lokogba, no farmers practice these types of crop management (Table 6). Fallow is mainly practiced by farmers (91%) of the village of Govié. In the village of Linsinlin, only short fallow practices are observed by 44% of farmers. These results show that the village of Lokogba is under land pressure unlike other villages where the pressure is still fair. Mulching is practiced in the village of Govié only by 18.7% of farmers. These crop management practices are significantly specific to villages studied at the 1%.

Crop protection practices

Crop losses recorded on farms are due to the damage caused by pathogens through diseases and pests. Preventive measures are implemented by farmers to limit the damage caused by pests. This practice (a soil conservation practice) is statistically specific to villages studied at 1% level. The most used preventive measures in the village of Govié are weeding (38.8% of farmers), traps (26.0% of farmers) and firewall (17.4% of farmers). In the village of Lokogba, weeding is an important preventive measure practiced by 93.8% of farmers. The preventive measures practiced by farmers from the village of Linsinlin are mainly weeding (23.2% of farmers) and firewall (19.2% of farmers). In this village, 53.6% of farmers do not practice any preventive measures (Table 7).

To combat pests, farmers use curative measures such as herbicides, rodenticides, insecticides and aqueous extracts. These curative measures are specific practices that significantly discriminate the surveyed villages at 1% level. Herbicides are used by 11.6% of farmers from the village of Lokogba and rarely used by farmers of Govié village (2.2%). The most used herbicides are Kalach, Lagoon and Glycol. These are bought at the market and sprayed at a dose of 4 L ha^{-1} at least one month before sowing and flowering weeds. Farmers in Linsinlin village do not use herbicides.

Unlike herbicides, farmers in the villages use insecticides against pests. Insecticides are used by the majority of farmers of Lokogba (79.4%). These are K-Lambda Super and K-Optimal sprayed at a dose of 0.5 L ha^{-1} and the Pacha at a dose of 1 L ha^{-1}. These insecticides are purchased supplied by the extension services or CARDER. Crops receive insecticide treatment weekly for three weeks. All farmers of Linsinlin village use insecticides such as K-Lambda Super, Dimethoate and Cypercal. These insecticides are mostly purchased at CARDER and are sprayed at a dose of 0.75 L ha^{-1} in 3 to 4 times weekly applications. The treatments involved after flowering. In the, Rotenticides are used by farmers (9.4%) in the village of Govié only. The use of aqueous plant extracts to combat pests is a recommended soil conservation practice, but is observed rarely in Lokogba village only (5.2% of farmers).

DISCUSSION

Soil conservation is the prevention of soil from erosion or reduced fertility caused by overuse, acidification, salinization or other chemical soil contamination. Slash-and-burn and other unsustainable methods of subsistence farming are practiced in some less developed areas. Degradation of chemical and physical

Table 7. Crop protection practices.

Variables	Modalities	Frequency (%)			Total	Chi-square	Probability
		Govié	Lokogba	Linsinlin			
Preventive measures	No measures	20 (9.1)	3 (2.3)	57 (57.6)	80 (17.9	291.2	0.000
	Firewall	38 (17.4)	-	19 (19.2)	57 (12.8)		
	Weeding	85 (38.8)	120 (93.8)	23 (23.2)	228 (51.1)		
	Trap	57 (26.0)	-	-	57 (12.8)		
	Hunting	17 (7.8)	-	-	17 (3.8)		
	Scarecrow	-	4 (3.1)	-	4 (0.9)		
	Early harvest	2 (0.9)	1 (0.8)	-	3 (0.7)		
Plant protection measures	Herbicides	3 (2.2)	18 (11.6)	-	21 (5.4)	343.4	0.000
	Insecticides	9 (6.5)	123 (79.4)	96 (100.0)	228 (58.5)		
	Rodenticides	13 (9.4)	-	-	120 (30.8)		
	Aqueous extracts	-	8 (5.2)	-	13 (3.3)		
	No pesticides	114 (82.0)	6 (3.9)	-	8 (2.1)		

Source: Field Survey, 2013.

properties following land clearing is usually attributed to the aggressive climatic conditions, soil fragility and the rapid mineralization of organic matter, which increase losses by erosion and drainage. The high rate of soil degradation observed after land clearing is not, therefore, only caused by the accelerated erosion and leaching losses of plant nutrients. Land clearing removes biomass and leaf litter and exposes the soil.

Denudation and burning hasten the mineralization of soil organic matter. A rapid mineralization of humus, roots and surface plant debris continues even for a few years after clearing (Roose, 1986). This decline in organic matter content results in a decrease in the activities of mesofauna and microflora. Tillage causes detrimental changes in soil structure and fertility and greenhouse gas emissions (Mrabet, 2002). Intensive tillage tends to reduce soil organic matter (SOM) levels by causing oxidation of organic matter (Wood et al., 2000).

As SOM declines, soils become more compacted, less able to absorb and retain water, and more prone to water losses from evaporation and rapid run-off. Susceptibility to wind and water erosion increases, thus negatively affecting air and water quality (FAO, 2003). The number and the type of soil micro-organisms also decline, causing a reduction in the nutrient cycling and regulating services these communities provide (Millennium Ecosystem Assessment, 2005). Conservation tillage covers a range of practices which conserve soil moisture and reduce soil erosion by maintaining a minimum of 30% of the soil surface covered by residue after drilling. Generally, conservation tillage includes a shallow working depth without soil inversion, that is, no tillage or reduced or shallow tillage with tine or discs (Peigné et al., 2007). Conservation tillage leaves an organic mulch at the soil surface, which reduces run-off, increases the surface soil organic matter (SOM) promoting greater aggregate stability which restricts soil erosion (Franzluebbers, 2002). Reducing the intensity of soil tillage decreases energy consumption and the emission of carbon dioxide, while increasing carbon sequestration (Holland, 2004). The negative ecological consequences of mineral fertilizers have reached menacing proportions.

This concerns synthetic nitrogen in particular. It reduces the humus content and biodiversity in the soil, causes soil acidification and gives rise to emissions of nitrous oxide, a potent greenhouse gas causing climate change that will harm future food production. The rise in soil acidity diminishes phosphate intake by crops, raises the concentration of toxic ions in the soil, and inhibits crop growth. The depletion of humus in the soil diminishes its ability to store nutrients. Greenhouse gases derive from excess nitrogen that harms the climate (Kotschi, 2015). Chemicals (fertilizers and pesticides) in most Sub-Saharan African (SSA) countries have negative effects on human health and on the environment. In Benin there are 70 deaths in 2000 and 24 deaths in 2001, which were recorded in the cotton growing seasons due to poisonings by chemicals (IAASTD, 2009).

Risk of adverse health effects from pesticide use are often exacerbated in developing countries by poor access to information, farmers' illiteracy and unavailable or unaffordable protective equipment (Maumbe and Swinton, 2003). Knowing that farmers in the southern Benin are strongly integrated into a saving of commercial exchanges, we expected them to adopt most of the soil conservation practices that would have allowed them to maintain the level of income on increasingly small farms. But, paradoxically, this is not the case. These technologies have experienced a very low adoption rate despite the awareness of the farmers of the phenomenon

of land degradation (Floquet and Mongbo, 1998). For now, these technologies suffer from a certain irrationality compared to current socioeconomic conditions of farmers and the social relations they face. Eicher and Baker (1984) report the three main obstacles to the adoption of innovative agricultural techniques: the small size of farms and plots, the too great diversity of production and the technical competence of farmers.

Conclusion

Soil conservation practices such as clearing without burning, zero tillage, incorporation of residues in soil ridging perpendicular to the slope, use of organic fertilizers, mulching, crop rotation, fallow, preventive pests control and ecological control are observed in the studies watersheds. However, the adoption of these practices is very low. In the Govié and Lokogba watershed, soil preparation activities are more conserving than degrading contrary to Linsinlin watershed. In the other farming activities such as crop management and crop protection, Govié's farmers are adopted more soil conservation practices. The rapid population growth causing land pressure, reducing the size of farms, rural exodus leading to unavailability of agricultural workforce etc. constitutes obstacles to a widespread adoption of soil conservation practices.

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Conflict of Interest

The authors have not declared any conflict of interest.

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