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CHARACTERIZATION OF FARMERS' CROPPING SYSTEMS IN THREE DISTRICTS (BONOU, OUINHI, ZAGNANADO) OF BENIN REPUBLIC

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ABSTRACT

Objective of this study was to understand farmer's management practices related to water quality and sanitary issue in order to assess the risks of these practices especially in the Upper Ouémé Delta. All the data related to this investigation were collected by field observations, interviews, surveys of farming households and focus groups. The surveys were conducted with 387 farmers belongs to three districts of southern Benin (Bonou, Ouinhi, and Zagnanado). Results of study revealed that 97.48%, 57.78%, 76% of farmers respectively of the Bonou, Ouinhi, and Zagnanado districts grow food crops. Among these, 2.53%, 42.22% and 24% cultivate cash crops such as cotton and oil palm. According to survey results, soil conservation and tillage practices are widely practiced. Further, crops rotation and fallow are widely practiced in all studied districts and 84.84% of the surveyed farmers use chemical pesticides to maximize crop yields. Among these, only 2.32% farmers used aqueous extracts of *Azardichia indica* leaves for protecting crops against pests. The sources of the environmental risk are the type of chemical product on pesticide used, its toxicity, the parallel circuits of provisioning of pesticides, and the lack of use of protection clothes for spraying these products. This practice allowed ground and water pollution and leads to public health matter. A promotion of good practices is essential for a durable exploitation of the natural resources of the Upper Delta of Ouémé area.

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1 Introduction

Agriculture employs a large number of assets in the world and especially in the underdeveloped countries. It remains main economic activity in developing countries. This is an activity practiced in a traditional way for family consumption and national self-sufficiency. It is supplemented in some underdeveloped countries by cash crops such as cotton, cocoa, coffee or fruit (Hauchart, 2007). Limited availability of the land and rapid population growth are forcing farmers to increase agricultural productivity to ensure sustainable production. For this, varieties of cultural practices are implemented, but they also have effects on the environment. misuse of pesticides and chemical fertilizers, irrigation, tillage, plant hormone applications, stubble burning, planting without rotation and inappropriate animal wastes are some of the bad cultural practices (Shujaat et al., 2013).

In Benin Republic, agriculture is the main source of cash inflow throughout the country and cash crops are playing much important role (Koudokpon et al., 1994). Its contribution to gross domestic production (GDP) is 36% and it is achieved by the activity of ¾ of the active population (Soulé, 2012). It also contributes more than 85% to official export earnings (Soulé, 2012). Further, climate and soils also favor the diversification of agricultural production and allow production to cover essential basic food needs. However, excessive agricultural activities sometimes, caused damages to the natural resources. Indeed, some agricultural practices used currently, such as slash and burning of agriculture waste, excessive use of chemical inputs and continuous cropping creates environmental issues. People express increasingly growing need to occupy new lands, which results in the destruction of vegetation, declining wildlife and shrinking grazing areas. All these practices

expose populations to health hazards (dermatological infections, respiratory infections, etc.) linked to the use of chemical inputs in production areas.

It is therefore necessary to be familiar with the agricultural practices currently being implemented in Benin republic in order to understand their impacts on human health and the environment. Some studies have already been carried out (Soclo, 2003; Yehouenou et al., 2014) to understand the impact of farmers activities or pesticides residues on the groundwater and surface water contamination in cotton growing areas and market gardens, but information related to the upper Delta of Ouémé, a highly agricultural area are not available.

This study has been carried out to provide a better knowledge of different agricultural practices used in the Upper Delta of Ouémé, Benin Republic. Further, the study is also conducted to understand the impact of these agricultural practices on the environment and the health of residents. This will help in foresee technological packages for sustainable agriculture in the study area.

2 Materials and Methods

2.1. Study area

This study covered three districts (Bonou, Ouinhi and Zagnanado) of southern regions of Benin Republic (Figure 1). These districts are characterized by two rainy seasons and two dry seasons of unequal importance. Among this, the district of Zagnanado is located on the plateau of Zagnanado, the smaller trays north depression of LAMA between 7° to 7° 30' North latitude and 2° 15' to 2° 30' East longitude. It has a total area of 750 square kilometers

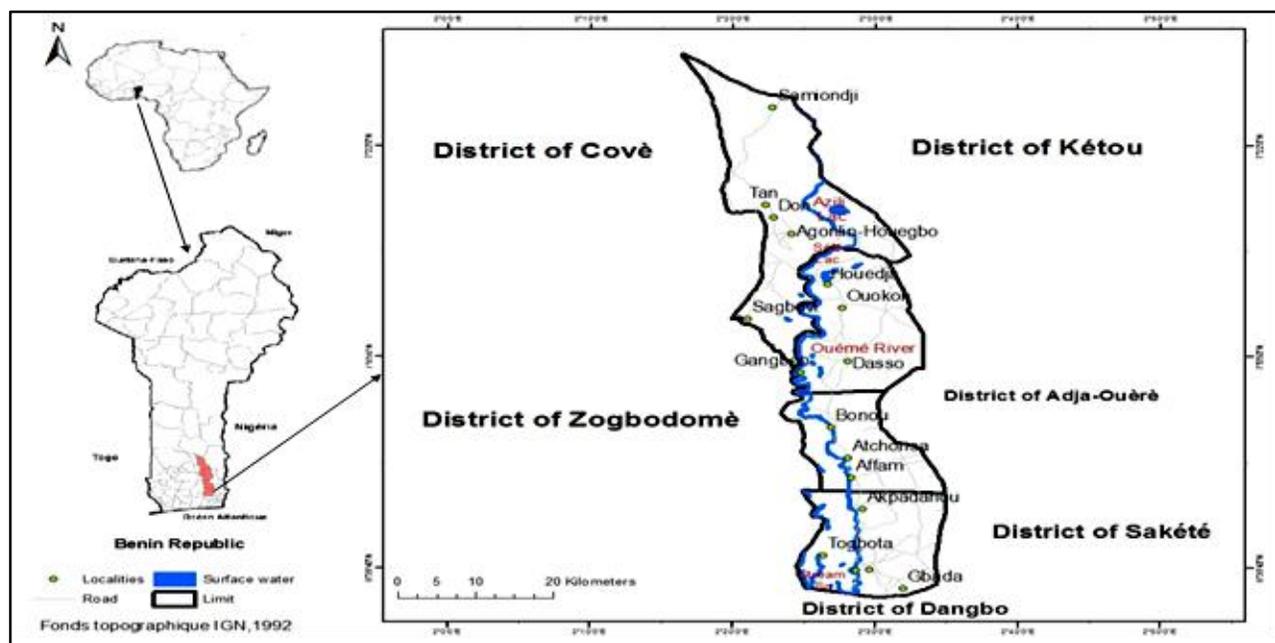


Figure 1 Geographical location of the study area

(Km) and is bounded to the North by the district of Dassa-Zoumé, South by Ouinhi and Zogbodomey districts, to the East by the districts of Ketou, Adja-Ouèrè and to the West by Covè, Za-Kpotaand Djidja. Second district Ouinhi covering an area of total 483 km², is located between 6° 57' to 7° 11' North latitudes and 2° 23' to 2° 33' East longitudes. It is limited to the northwest by the district of Zagnanado, southwest by the district of Zogbodomey. On the south side, it is limited by the district of Bonou at the east by the district of Adja-Ouèrè. The third and last selected district is Bonou. It is located between 6° 72' to 6° 95' north latitude and 2° 15' to 2° 40' East longitude. It is bounded on the North by Ouinhi, South by the Adjohoun, to the East by the districts of Sakété and Adja-Ouèrè and West by those of Zè and Zogbodomey and covers a total area of 250km² (INSAE, 2015). All three studied districts have lateritic soils, which favor the cultivation of annual crops (maize, cassava, beans, sweet potatoes and peanuts) as well as perennial (oil palm plantation, teak and acacia).

2.2. Selection of Respondents

Surveys were conducted with 387 farmers residing on the study area, from last twenty (20) years because below this age, people do not practice agriculture as a main activity, but as an occasional activity or to help their parents. They do not therefore master all the outlines of agricultural activity. These respondents were chosen randomly as a representative sample of the four ethnic groups (Mahi, Fon, Wémè, and Holli) (Table 1). Surveys were conducted in all the selected areas (Bonou, Zagnanado and Ouinhi) by personal interview. During this, the data were collected using a questionnaire developed and reviewed from the results of the exploratory phase of the study. Questionnaires were based on the

Table 1 Socio-cultural status of the surveyed Districts

Districts	Number of surveyed respondents	Localities	Percentages by Localities (%)	Ethnic group
Bonou	131	Affame	10.4	Wémè
		Atchonsa	4.0	Wémè
		Dame-Wogon	0.4	Wémè
		Houinvigie	6.5	Wémè
		Bonou	4.3	Wémè
Ouinhi	125	Dasso	6.8	Mahi
		Sagon	15.8	Fon
		Tohoue	6.1	Mahi
		Ouinhi	14.7	Mahi, Holli
Zagnanado	131	Agonli-Houegbo	1.8	Mahi
		Dovi	10.4	Mahi
		Kpedekpo	15.1	Fon, Mahi
		Zagnanado	3.6	Fon

qualitative factors such as work experience, education level, type of training, crops, farming practices. The farming practices are about clearing, tillage, fertilization, crop rotation, pest management and fallow, application periods and equipment used, supply chains, mode of storage of agricultural inputs, management of empty packaging, the perception of farmers on environmental and health impacts. Results of individual interviews were also supplemented by the interviews conducted with resource persons (CECPA staff, CARDER staff, etc.). Direct observations have focused on different agricultural practices. The size of the sample (N) is obtained using the normal approximation of the binomial distribution according to Dagnelie (1998). The required sample size can be calculated by following formula:

$$N = [(U1-a/2)^2 \times p(1-p)] / d^2$$

With $n \geq 50$ and $p \geq 1/10$ of population, N = sample size required per village of study; $U1-a/2$ = 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).

2.3. Processing and analysis of data

The data were processed with a spread sheet, Microsoft Excel and analyzed with SPSS (Statistical Package for the Social Sciences) Version 16.0 in order to have a descriptive statistics (percentages, averages, standard errors etc.). The Chi square test was conducted to statistically verify if there is a dependency between agricultural practices and districts and to inform us about the specificity of farming practices in relation to districts studied.

3 RESULTS

3.1. Characteristics of the sampled farmers

Table 2 shows the profiles of the studied respondents (farmers) in the three districts of Upper Delta Ouémé in Benin. Education and social-demographic characteristics are the two main characteristics of the farmers which are importantly considered in this study. Further, the studied population consists mainly of farmers whose age range is between 30 and 75 years with an average of 43 years. The average age of household heads are reported 40 years in Bonou while it was reported 44 years in Ouinhi and Zagnanado districts (Table 2).

Among the studied field, 77.3% of the fields are possessed by native people and these have agriculture as their main activity. The number of non-native respondents is very low. Farmers are also involved in the fishing, trade, and hunting, 56.7% among them are not educated. However, 58.2 % of Zagnanado's farmers are educated as compared to those of Bonou (35.7%) and Ouinhi districts (37.1%). Regarding gender, 92.4% of respondents were male and 7.6% were women. This low rate of women farmers is

explained by the fact that access to land is rather difficult in the study area and that land ownership is not available to female farmers. Women are more specialized in trade, processing of agricultural products and fishing. In case of farming experience, 92.8% of the respondents have more than 10 years' experience (Table 2).

3.2. Important Crops Cultivated in the study area

The main crops widely cultivated are maize, rice, cowpea, peanuts, cassava, yam, pepper, tomato. As cash crop, farmers usually grow oil palm and cotton. Among the surveyed respondents, 77.2% produced food crops for their food security while 22.8% produced cash crop for direct income generation.

3.3. Farming systems adopted in surveyed districts

3.3.1 Agricultural equipment used by study area farmers and soil preparation practices

The results of the survey revealed that farmers are far from using motorized agricultural equipment and that all the producers use traditional tools that are rudimentary materials made by local craftsmen (hoes, machetes and cans). These rudimentary tools no longer allow users to have a large production, especially when they are elderly. In order to carry out phytosanitary treatment operations, 90.2% of the farmers surveyed use sprayers while the rest of the farmers use traditional or handmade equipment, such as watering cans, buckets or bottles. Farmers of the surveyed districts (Bonou, Ouinhi and Zagnanado) usually used two (02) types of soil preparation techniques: clearing without burning, and clearing with burning. The technique of burning is usually applied for clearing of new land or land left fallow. It is practiced by 40.6% of farmers while 59.4% used land clearing without burning technique. The shifting cultivation is the main cultivation technique which is used by the study area respondents. Depending on the crop (tuber or grain) and soil types (deep, skeletal), farmers used ridges or mounds techniques for sowing. Mounding techniques are used by 33.6% of respondents, while the rest of the respondents used ridges techniques. Different soil preparation practices are significantly specific in to studied district, clearing and tillage type at the 1 %.

3.3.2. Crop management practices

Crop rotation, fallow and intercropping (soil conservation practices) are the some crop management practices which were frequently adopted by the farmers of the studied sites. Among these, crops rotation is widely practiced (45.6%). The order of crops rotation allows farmers to benefit from back effects of chemical fertilizers, and helps crops to fight against some weeds. Crop rotation is followed by the fallow (36.9%). These results show that the studied site is under land pressure unlike other

Table 2 Social and demographic characteristics of farmers of all three surveyed districts

Variables	Modalities	Frequency (%)		
		Bonou	Ouinhi	Zagnanado
Gender	Male	95.8	94.2	87.2
	Female	4.20	5.80	12.8
Age	30-40 years	62.7	36.7	44.7
	40-50	28.4	40.8	40.0
	50-60	4.50	16.7	9.40
	> 60 years	4.50	5.80	5.90
Origin	Native	85.9	72.7	76.7
	Immigrants	14.1	14.9	5.80
Level of education	Illiterate	64.3	62.8	41.9
	Primary level	24.3	22.3	44.2
	Secondary level	11.4	14.0	14.0
	University level	0.00	0.80	0.00
Experience in agriculture	5-10	4.20	5.00	8.10
	>10 years	91.5	94.2	80.2

villages where the pressure is still fair. Intercropping is practiced by 73.2% of the farmers (Table 3) while monoculture is practiced by only 23.29% of the surveyed farmers. This practice constitutes a genuine threat to food security due to land exhaustion. In the districts concerned, another practice is to divide cultures between

Table 3 Crop management practices followed by the respondents of the study area

Variables	Frequencies		
	Bonou	Ouinhi	Zagnanado
Fallow	37.2	45.0	27.0
Rotation	9.00	64.2	52.0
Crop association	44.9	95.8	68.0
Monoculture	69.2	37.5	34.0
Crop rotation	21.8	60.0	44.0

plots. This practice is done by producers who have a single field, or have a large field in a locality, or those whose lands are adjacent to the banks of rivers. These producers are 44.6% of the surveyed population.

3.3.3. Fertilization practices

Fertilization is a common practice. 33.6 % of the farmers used organic fertilizers (soil conservation practice) while 66.3% used mineral fertilizers. Among the mineral fertilizers, NPK (15-15-15) and Urea are the most commonly used. In case of organic fertilizer, most of the studied respondents used household garbage, compost and animal wastes. A highly significant relationship was reported between fertilization and studied villages watersheds ($\chi^2 = 25$).

412; $p = 0.000$). So, fertilization is a practice that significantly discriminates the surveyed sites. 10.4% of the studied farmers used both inorganic and mineral fertilizers. However, during the survey, it was reported that 15.4% farmers did not use any fertilizer for their crops.

3.3.4. Crop protection practices

During the survey, it was reported that all the studied respondents are aware about crop losses due to the attack of pathogen, insect and pest. To combat pests, farmers use curative measures such as herbicides, insecticides and aqueous extracts of plants. Six major classes of chemical pesticides, which are widely used by study area respondents to protect their crop are: organophosphates, organochlorines, carbamates, amino phosphonates glycine, pyridines and Pyrethroids. (Table 4; Figure 4). Among these chemicals, the active ingredients amino phosphonates glycine (42.8%) were the most frequently used and it was followed by Pyrethroids (28.5%), organophosphates (21.4%), organochlorines (7%) and carbamates Pyridines (7%) (Figure 2). The use of prohibited active ingredients was not reported during this survey.

Pesticides are used by 86.5% of farmers. Insecticides and herbicides are the categories of pesticides used. 23.2% of

farmers used insecticides and 11.8% used herbicides for weed control. The insecticides are widely used for controlling the infestation of caterpillars, moths, sucking insects, and aphids (Figure 3). The herbicides are sprayed on the space occupied by quack grass (*Imperata cylindrica*). This action asphyxiates the growth of the species and protects the crops. The most commonly used herbicides are Zaki, Paraphos, Glyphogan, Sunsale, Tackle, Total and Force up. Among the surveyed respondents, 48.8 percent respondents used both insecticides and herbicides (Table 5).

Getting pesticides, insecticides and herbicides are also difficult for the study area farmers. During this study, three pesticides supply routes have been identified. Most of the farmers collect these chemicals from the approved agencies such as Communal Agricultural Promotion Center (CeCPA) and private distribution companies while some of the producer purchases these from the local markets. The third supply channel is Nigerian foreign market, which is not far from the three selected districts.

For performing insect pest management, 90.2 % of the surveyed farmers used knapsack sprayer while the rest of the farmers used traditional or handmade equipment such as watering cans, bucket and bottles for spraying (Figure 3).



Figure 2 Various pesticides used in Bonou, Zagnanado and Ouinhi districts



Figure 3 Protective equipment and sprayers used by farmers

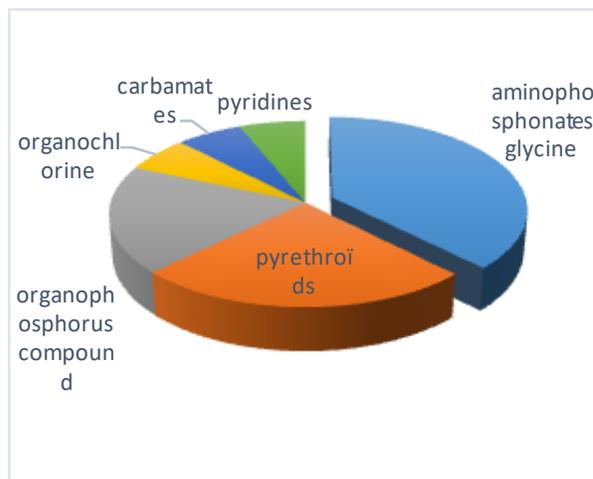


Figure 4 Distribution of active ingredients by chemical family

Table 4 Insecticides and herbicides used by the farmers of study area

Purpose	Product name	Composition and concentration	Chemical family	Chemical formulas	(WHO) Hazard class (WHO, 2009)	Origin	Nature
Insecticide for cotton field	Fariapermfos BC	Cypermethrin 10%	Synthetic Pyrethroids	C ₂₂ H ₁₉ Cl ₂ NO ₃	II	Benin distribution centers	Is extremely toxic to fish and freshwater invertebrates
	Profenofos	Profenofos 500g/l	Organophosphorus compound	C ₁₁ H ₁₅ BrClO ₃ PS	II	Benin distribution centers	Extremely dangerous
	Coton plus	Cypermethrin 72g/l Acétampiride	Synthetic Pyrethroids and Organochlorine compound	C ₂₂ H ₁₉ Cl ₂ NO ₃ C ₁₀ H ₁₁ ClN ₄		Benin distribution centers	Is extremely toxic to fish and freshwater invertebrates
	Cyper Action	Cypermethrin 10%	Synthetic Pyrethroids	C ₂₂ H ₁₉ Cl ₂ NO ₃	II	Nigeria market	
Other insecticides	Lambda Finer	Lambda-cyhalothrine 25	Synthetic Pyrethroids	C ₂₃ H ₁₉ ClF ₃ NO ₃	II	Nigeria market	Toxic to the aquatic environment Is extremely toxic to fish and freshwater invertebrates. Not registered
	Aminophos	Méthomyl	Carbamates	C ₅ H ₁₀ N ₂ O ₂ S	I b	Benin distribution centers	Highly toxic in freshwater fish and extremely toxic in aquatic invertebrates High leaching potential
Herbicide	Zaki	Paraquat 20%	Bipyridylum derivative	C ₁₀ H ₈ N ₂	II	Nigeria market	Very toxic to aquatic life with long lasting effects Fatal if inhaled
	Paraphos	Chlorofenizon (20 %) Parathion-ethyl (10 %)	Sulfonates and Organophosphorus	C ₁₂ H ₈ Cl ₂ O ₃ S C ₁₀ H ₁₄ NO ₃ PS	I a	Nigeria market	Very toxic to aquatic life with long lasting effects Fatal if swallowed
	Glyphogan	Glyphosate 180g/l et terbuthylazine 345g/l	Aminophosphonates glycine Organophosphorus compound	C ₃ H ₈ NO ₅ P	III	Nigeria market	
	Sunsale	Glyphosate isopropyl ammonium 480g/l	Aminophosphonates glycine	C ₃ H ₈ NO ₅ P	III	Nigeria market	Potential low risk
	Tackle	Glyphosate 360g/l	Aminophosphonates glycine	C ₃ H ₈ NO ₅ P	III	Nigeria market	Does not accumulate in fish and other animals
	Total	Glyphosate 360g/l	Aminophosphonates glycine	C ₃ H ₈ NO ₅ P	III	Nigeria market	Rapid degradation
	Force up	Glyphosate 360g/l Glyphosate isopropyl ammonium 480g/l	Aminophosphonates glycine	C ₃ H ₈ NO ₅ P	III	Nigeria market	
	Finish	Glyphosate 360g/l	Aminophosphonates glycine	C ₃ H ₈ NO ₅ P	III	Nigeria market	

Ia = Extremely dangerous; Ib = Highly dangerous; II = Moderately hazardous; III = Slightly hazardous; U = Does not appear to present a hazard under normal conditions of use; O = Pesticide obsolete, unclassified.

Table 5 Important agricultural practices adopted by the study area farmers

Variables	Modalities	Percentages			Chi-Square χ^2	Probability $\alpha < 0.05$
		Bonou	Ouinhi	Zagnanado		
Fertilizers	Mineral	65.4	79.2	59.0	25.412	0.000
	Organic	1.30	2.50	12.0		
	Mixte	9.00	10.8	11.0		
	No fertilizers	24.4	7.50	18.0		
Management of pests	Pesticides	87.2	85.7	87.0	16.071	0.013
	Aqueous extract	1.30	1.70	1.00		
	Mixed use	1.30	10.9	7.00		
Type of pesticides	Insecticides + Herbicides	85.9	57.1	48.00	99.996	0.000
	Insecticides	0.00	31.1	32.0		
	Herbicides	14.1	8.40	14.0		
Storage of pesticides	Inside the house	64.1	54.6	51.0	27.604	0.000
	Stores	1.30	10.9	7.00		
	In the fields	14.1	30.3	35.0		
Treatment of empty packaging	Recycled / reused	1.30	14.3	8.00	1.344	0.000
	Throws	88.5	33.0	59.0		
	Buried	0.00	37.4	14.0		
	Burned	10.3	3.30	0.00		
Spreaders	Backpack Sprayers	82.1	95.8	90.0	11.291	0.023
	Bottles and Branches	6.40	2.50	5.00		

During spraying of chemicals, very fewer producers (less than 10 %) use complete recommended protective gears, which are necessary for their protection. Most commonly used protective gears are gloves, boots, goggles, masks and makeshift noses, handkerchiefs, long-sleeved clothing and hats. Among the surveyed farmers, 52.3% of farmers preferred to use at least one protective gear during spraying while 39.6% of the producers did not use any protective gear. Some common arguments, used to justify the lack of protection, are the unavailability of equipment in the market, the excessive purchase cost of such equipment, the difficulty of changing clothes after spraying, lack of comfort at work, the wearing of protective equipment deemed unnecessary and negligence.

Some of the respondent's (7.1%) used, aqueous extract of neem leaves (*Azadirachta indica*) in addition to chemical pesticides. Very few producers (1%) used only neem aqueous extracts for the management of the insect pest. The use of the aqueous extract of neem leaves is vulgarized by structures such as Benin National Institute of Agricultural Research (INRAB) and Cowpea Project for Africa (PRONAF).

3.4. Local perception of farmers regarding the health effects of pesticide inputs

The impacts of pesticides on health are not well perceived by producers. The symptoms commonly observed by farmers during and after field spraying were skin burns, headache, blurred vision, hand shaking, severe coughing, stomach pain (Ranging from simple cramps, nausea to vomiting), respiratory problems, colds,

skin irritation, and dizziness. These symptoms are felt by 83% of the farmers of Zagnanado district, 79.5% of the Bonou farmers and 92.5% of the farmers in the district of Ouinhi. To mitigate the effect of these chemicals, farmers used rudimentary methods such as the use of coatings (mentholatum in the nostrils), consumption of leafy decoction, washing the body with soap and consuming milk "Peak" after each treatment.

3.5. Farmers' perceptions regarding the impact of used agricultural activities on the environment

In prepared questionnaire, some question related to the impact of farmer's agricultural activity on the quality of various environmental constitutes, was also incorporated. Among the studied respondents, 57.0% of the respondents believed that the use of pesticides can be dangerous to humans and environment while 23.0% of the respondents did not have any opinion on this issue and rest 20.0% producers believed that they did not face or observed any negative effects on the environment and humans during or after spraying these chemicals. Some of the common impact which was identified by the surveyed area respondents are declining soil fertility, destruction of soil fauna, soil depletion, fish poisoning and mortality, poisoning in animals or human being, the prevalence of diseases related to the use of products, contamination of human food products, water contamination by pesticides, soil erosion, loss of vegetation, filling of streams. Similarly, producers establish a relationship between the risks of contamination of water and fish by pesticides and toxic hazards for humans who consume them. On the other hand, for the soil, the answers are mixed.

According to them, the use of pesticides would contribute to strengthen and maintain its fertility.

4 DISCUSSION

4.1. Agriculture and Cultural practices

Agricultural practices are considered as the whole process and mode of action of farmers. Thus, they include the technical management of the farm and the management of the cropping system (Pourias, 2014). The cultural practices identified in studied districts (Zagnanado, Bonou and Ouinhi) have generally positive and negative consequences on the environment. In the first stage of the crop cycle, most of the farmers adopted manual cleaning, which preserves useful stumps and trees and don't disturb the root network or the superficial horizons of the soil (Roose, 1985). Slash-and-burn method, which contributes in soil degradation, is widely used. During this, high fumes are released and generate atmospheric pollution (ABE, 2002). According to Bertrand & Gigou (2000), fire destroys 80-90% of the plant matter during this practice. Available soil nitrogen is volatilized, and produced ash, is dispersed by wind or runoff, instead of enriching the soil. In addition, fire superficially modified the soil surface which reduced the soil porosity and increase runoff and soil erosion (Serpantié et al., 2001). However, slash-and-burn cultivation can be favorable when it is done in piles with spreading and burial of ashes during plowing (Bertrand & Gigou, 2000). In the south of Benin Republic, this method has been also identified (Kouelo et al., 2016). Traditional combination or intercropping saving cropping time and help in better labor management during the agricultural season (Kaboré et al., 1995). Further, intercropping not only provide better coverage of the soil surface, but also provide better nutrient supply, especially when they mix a cereal with creeping plants like cowpea. Mix cultivation reduced the risk of parasitic attack, disease and colonization by weeds and also provide protection against the aggressiveness of raindrops which reduced 36% crop production and lead to a reduction in water, land and nutrient losses by runoff (Maatman & Schweigman, 1995). Study area farmers are also familiar with the crop rotation which help in reducing parasitic and pest attacks and slows down the mineral and organic fertility loss of soils.

This study revealed higher use of chemical pesticides and fertilizers and the use of organic manure is not widespread among producers of these three districts. Chemicals (fertilizers and pesticides) in most Sub-Saharan African (SSA) countries have negative effects on human health and also on the environment (Kouelo et al., 2016). These results are contradictory with the findings of Bâ et al. (2016) in the Niayes area of Dakar (the Patted'Oie and Malika) Senegal, where organic fertilizers are commonly used by farmers. Sometime, excess uses of organic fertilizers have negative impacts on the ecosystem and sometime beyond the ecosystems. According to Ndiaye (2009), organic

manure, especially poultry droppings, has wide spectrum of pathogenic microorganisms and sometime these microorganisms reached up to the ground water table also. As far as inorganic fertilizers are concerned, the main ones used by farmers are NPK and urea. Cissé et al. (2003) and Bâ et al. (2016) reported the use of urea and NPK as a widespread practice across the Niayes in the Dakar region. Use of pesticides and mineral fertilizers can affect the quality of soils by making changes in the physical and chemical properties of the soil (Le Clech, 1998). Indeed, higher uses of mineral fertilizers (NPK) have acidifying effect by the reduction of the organic carbon content in the soil. Two pesticides belonging to WHO classes Ia and Ib are applied to the crops in the study area (Table 4; WHO, 2010). Obopile et al. (2008) and Diop (2013) reported excessive use of pesticides containing active ingredients classified as extremely or highly hazardous in Botswana and the Niayes region of Dakar. This situation can be explained by the weak enforcement capacities of the pesticide regulations in Benin as in most underdeveloped countries. The main cause of this is the lack of human, material and financial resources. The consequences of this non-application of the regulation by the farmers are the presence of informal supply chains, the bulk and unlabeled repackaging of pesticides, the uncontrolled multiplication of phytosanitary products outlets, the presence on the market of counterfeit, sub-dosed or over-dosed products that cause loss of efficacy, insect resistance phenomena and potential risks to human health and the environment, lack of Marketing qualifications of retailers and street sellers, lack of import controls, and cross-border flows from Nigeria and Togo (Matthews et al., 2003).

Most of the surveyed respondents used manual backpack sprayers for the application of phytosanitary products. Similar results were reported in Ghana by Ntow et al. (2006) and in Dakar (Senegal) by Diop (2013). The use of these equipments is also risky because most of the used backpack sprayers have frequent leakage of liquid. In addition, the high cost of sprayers does not favor the replacing of old equipment which is generally poorly maintained. Matthews et al. (2003) reported only 25% suitable sprayers in Cameroon. Other materials (watering can and plant branches) used for the treatment of pesticides have been also identified by various researchers in Central Africa, Côte d'Ivoire and Togo (Doumbia & Kwadjo, 2009; Sougnabe et al., 2010; Kanda et al., 2013). On the other hand, it was reported that level of protection equipment during spreading is very low. This situation has already been depicted by PAN Togo (2005) and OBEPAB (2006). During spraying, air became polluted and fully loaded with aerosol particles that would be inhaled by the inhabitants near the fields. Dumler et al. (1993), and Guissou et al. (1996) reported higher risk of pesticide poisoning in those cotton producers who had long-term exposure of pesticide contaminate air without adequate protective equipment. According to Kankou (2004) and Gomgnimbou et al. (2009), the lack of personal protective

equipment increases the risk of poisoning, which can become serious by bioaccumulation.

The study of the pesticide supply routes revealed three circuits, namely the formal one, the local market and the external market. Similarly, Sougnabé et al. (2010) also identified similar three pesticide supply routes in Chad, Cameroon, and the Central African Republic. Official channels for the distribution of pesticides in these three countries are not controlled, hence the proliferation of the informal sector. Four distribution channels have been identified by OBEPAB (2006) in Kobe, Déni and Okéowo in northern Benin. In the Banikoara district, 33% of producers rely on the informal sector which belongs to Togo, Nigeria, Ghana etc. (Agbohessi et al., 2011). Diop (2013) also showed that 61.5% of market gardeners in the Niayes district of Senegal were supplied with phytosanitary products from non-approved retailers.

4.2 Perceptions of environmental and health impacts among farmers

Agricultural practices related to phytosanitary treatment, application of fertilizers and the use of agricultural chemical inputs for other purposes have negative impacts on human health. 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 & Swinton, 2003). During the exposure, the operator feels only minor disturbances, but in the long term, various disease and disturbance may appear (INRS, 2007). Result of study revealed the farmers ignorance toward the environmental and health risks related to the use of the chemical inputs. Some other African researchers also reported farmer's ignorance (Dolumbia & Kwadjo, 2009; Thiam & Sagna, 2009; Diop, 2013). Further, Sougnabé et al. (2010) and Gomgnimbou et al. (2010) also reported that farmers involved in cotton cultivation in Chad and Burkina Faso did not have a good knowledge of the active ingredients of the pesticides used and their impacts on human health. The symptoms listed by the producers in the study area are skin irritations, headaches and stomach ache. Discomforts such as vomiting and dizziness are also cited by producers as cases that often occur. Similar symptoms were recorded by Adjagodo et al. (2016) in the lower Ouémé valley in Benin Republic, by PAN Togo (2005), OBEPAB (2006), Toé (2007) and Ouattara (2008) in cotton producers of the West African region.

For better management and protection of the environment, humanity developed a new perspective to decrease the negative effects of agriculture which is sustainable agriculture. This allows good agricultural practices, organic agriculture and precision agriculture. Also rotation, sowing of legumes that able to nitrogen fixation reduces the negative effect of agriculture on environment. Farmers must turn to agricultural techniques for soil conservation, pest management that can preserve their health, and environment.

It is necessary to find alternative solutions to limit the use of chemical inputs.

Conclusion

Through this study, the elements to be retained are that farmer's practices such as the use of organic fertilizers, crop rotation, fallow, preventive pest control and ecological control are observed in studied districts. However, the adoption rate of these practices is very low. In the studied districts, agricultural activities are more degrading than conserving environment. The lack of sustainable strategies for strengthening production (soil amendment, agroforestry, etc.) and the lack of perception of environmental risks, linked to agricultural intensification, are points to be considered in the development plans, in order to allow a better integration of all agricultural activities in the study area. New crop management systems capable to reduce reliance on pesticides, such as aqueous extracts and biopesticide, should be promoted. Integrated crop management, well understood and properly applied, can contribute to good results with minimal impact on the environment. Its implementation requires the intensification of sensitization. Experimental protocols should be developed to study some environmental compartments that could suffer from agricultural damage.

Conflict of interest

Authors would like to declare that there is no conflict of interests that could possibly arise.

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