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# Study of pesticides use conditions in cashew production in Côte d'Ivoire

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**This work aims to promote the rational use of agrochemicals in cashew cultivation by evaluating health prevention culture and environmental preservation levels in cashew producers' practices in Côte d'Ivoire. A cross-sectional study was conducted from April 2017 to August 2018 in the 3 main cashew production areas (Mankono, Dabakala and Bondoukou). A total of 386 cashew farmers randomly selected were interviewed using the face-to-face technique with an anonymous structured questionnaire. Our results revealed that 68.9% (n=266) of the producers surveyed used agrochemicals but were essentially illiterate (66.04%) and relatively aged with 45 years in mean. Mankono represented the major site in pesticides use with mean of 10.6 L herbicide per hectare following Dabakala (2.5 l/ha). 70 different specialties were identified among them; 38.20% were not approved in Côte d'Ivoire. 11 active substances were identified. The controversy herbicide glyphosate was the most abundant active molecule used following 2,4-D amine salt. Several cases of acute intoxication (headache, nausea, etc.) were reported in 37.6% of producers who applied pesticides twice in every agricultural year for 2 to 4 h and in some cases (26%) within 1 and 4 pm without efficient protection. Concerning environment protection, 61.70% applicators abandoned pesticide packaging in the wild indicating poor environment regarding farmers' practices. Taken together, our results suggested that the conditions of pesticide use were a real handicap for the sustainability of the cashew farming which could be improved by farmers training in safe use and rigorous control by the Ivorian Government.**

**Key words:** Pesticide-safe-use, cashew-nuts-production, agricultural-practices.

## INTRODUCTION

Introduced in the North of Côte d'Ivoire at the end of the 1950s by Government programs of reforestation due to its rapid growth and its rusticity, cashew was until the early 1990s exploited for its wood (Sinan et al., 2017).

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But since the beginning of the 2000s, cashew plantations have emerged gradually as income-generating speculation in front of cotton (Sinan et al., 2017). Thus, the production of cashew has been very intensive in Côte d'Ivoire since 2015 with annual productions estimated at 700 thousand tons representing a rate of 21% of the World offer. Côte d'Ivoire is currently the world leading producer and exporter country of cashew. More than 250 thousand producers are concerned by cashew which represents the main source of income of approximately 1.5 million Ivorian people (Lebailly et al., 2012).

The value of exports in 2015 of cashew was estimated at more than 650 million $ US that rise cashew to the rank of the 3rd most important export after cocoa and refined petroleum products. However, despite the intervention of agricultural support and supervision structures, the production of cashew as other crops, remained heavily dependent on climatic conditions (Afouda et al., 2013).

Rainfall irregularities and temperature increasing made cashew tree cultivation vulnerable to undesirable organisms (weeds, insects, fungi, bacteria, etc.) and which were probably the cause of significant yields decrease and the depreciation of nut quality (Koné et al., 2017). It had been reported that undesirable organisms could cause considerable damage that might result in some cases to production losses of more than 30% (Ouedraogo et al., 2016).

Therefore, cashew nut growers increasingly used chemical control by pesticides to stem parasites of the culture and fight against weeds. The term pesticide covers a wide range of compounds including insecticides, fungicides, herbicides, rodenticides, molluscicides, nematicides, plant growth regulators and others. Ideally a pesticide must be lethal to the targeted pests, but not to non-target species, including farmers (Ba et al., 2016). In addition, abuse of pesticides may be a source of environmental pollution (Diop, 2013). Indeed, the major sources of pesticides pollution were industries, agriculture, forestry and domestic activities (Ericson, 1989). However, pesticides pollution through air had also been reported. The dust particles in the air absorbed the pesticides due to spray application in agriculture and then contaminate water bodies, sediments and soil through rain water (Ericson, 1989; Ali and Jain, 1998).

Adverse effects due to pesticides included the phenomena of resistance due to habituation of predators to chemicals used (Georghiou ,1986), degradation of natural resources, persistence of pesticide residues in products and agricultural by-products (Diop, 2013) which could be a source of chronic exposure in human or animal consumers. Indeed, several pathologies such as cancers, the sterilities, birth defects, diminished intelligence, neurological disorders and reproductive and Parkinson's disease have been associated with long-term exposure of pesticides at low-dose (Rainaud, 2013; Batsch, 2011). Such pathologies were very difficult to attribute to chemicals after chronic exposure at low-dose. So the protection of human health and environment against agrochemicals remained a problem in the practices of African producers generally and particularly for Ivorian cashew producers (Boyd, 2007). That could constitute a barrier to the sustainability of cashew production in Côte d'Ivoire. Indeed, the sustainability of crops production supports the production of crops by protecting environment and health and safety of farmers. Thus, the aim of our study is to promote rational pesticides uses in order to mitigate occupational risks for pesticides users, to ensure cashew nuts safety and the preservation of the ecosystem. Our study explored essentially acute toxicological profile of agrochemicals identified, occupational risks reported from farmers, protection equipment available and management of pesticides empty packaging by farmers.

## MATERIALS AND METHODS

### Study areas

Field work (surveys, interviews) was carried out in the departments of Mankono, NorthWest, Dabakala in the North-Central and Bondoukou, East of Côte d'Ivoire. These departments represent the three largest cashew nut production areas in 21 areas of the country. They basically cover an area of 23310 $km^2$ and polarize more than 223 villages according to the shapefile data of 2010 from the towns and villages of Côte d'Ivoire (National Bureau of Technical Studies and Development (BNETD)). To carry out our study, a stratification of localities based on the importance of cashew nut production was performed and 20 localities were randomly selected among the total list of producers conformed to our criteria. These 20 localities included 10 in Mankono, 5 in Bondoukou and 5 in Dabakala.

### Study population

As inclusion criteria, this study is concerned exclusively with the cashew producers belonging to one of the localities of strong productions identified by the partners namely the National Rural Development Support Agency (ANADER) and the Cooperative Society of Agricultural Producers of Bondoukou (COPABO). In addition, the surveyed producer must have a farm in production with a greater or equal to 1 hectare in order to include in the study only representative producers.

### Study material

For this study, a structured questionnaire was used to collect the data. The questionnaire was structured in 2 parts. The first part was consecrated to describe the socio-demographic profile of producers and to identify and characterize pesticides used in the culture of cashew at Dabakala, Mankono and Bondoukou. The second part analyzes the farmers' practices in the use of pesticides. The TECNO CAMON CM mobile phone in which the MOBILE TOPOGRAPHER application was downloaded allowed us to take some photographs and record GPS coordinates during the surveys.

**Study method and technique**

***Type and period of study***

This is a cross-sectional study with a descriptive purpose which was conducted in two phases during the period from April 2017 to August 2018. The first phase, which took place from April to June 2017 consisted of the pilot survey. The second phase was the actual survey. It took place from January to August 2018.

***Survey technique and sample size***

On the base of the total producers in the 20 localities as identified, the sample size of volunteers surveyed in every department was calculated (Kayungura, 2009):

$$\text{Sample size} = [((U_{1-\alpha/2})^2 \times p\,(1-p)) / e^2] / [1 + ((U_{1-\alpha/2})^2 \times p\,(1-p)) / e^2 \times N]$$

With: U1 - α/2 = 1.96 (95% confidence level); P = 0.8 (proportion of producers with the studied characteristic calculated during the exploratory study); e = 0.05 (the margin of error); N = 805 (the size of the population).

So, with a population of 805 producers, a sample of 386 producers was established such as Mankono (147), Dabakala (125) and Bondoukou (114). That was well above to the minimum sample size of volunteers required for our study which was 189 producers. After determination of sample size, a systematic random sampling was used to select producers satisfying the inclusion criteria as described previously in the database of our partners ANADER and COPABO.

***Collection technique***

For this study we administered a face-to-face questionnaire. This work was carried out in close collaboration with ANADER's cashew nut farm advisors (CCAs) and COPABO's quality manager, who facilitated our meetings with producers. An incognito observation allowed us to have, among other things, a global idea of pesticide use in order to verify the data from the questionnaires.

***Variables studied***

We studied three groups of variables from producers of cashew nut: Firstly, the socio-demographic variables (gender, age, level of education and knowledge), secondly, characteristics of pesticides variables (type of formulation of products, licensing, frequency of use, class of acute toxicity according to World Health Organization classification) and finally agricultural practices variables in the use of pesticides (time and frequency of exposure, type of packaging, duration of management applications, different clinical signs caused by pesticides, personal protective equipment and management of pesticides empty packaging).

***Data processing and analysis***

After processing the survey sheets, the data were coded, entered and analyzed using Sphinx 4.5.0.30 and Excel version 2010. The data were summarized in tabular and graphical form.

## RESULTS

### Socio-demographic data of cashew nut producers

***Gender and age of cashew nut producers***

The survey in the three largest cashew nut production areas revealed that the majority of producers interviewed were males 94% (n=363) compared to 6% (n=23) females, or a sex ratio of 16 men to 1 woman. In these different production areas, the average age of the producers surveyed was 45 years with a range from 18 to 75 years.

***Educational level of operators***

In terms of literacy, the survey revealed that 66.04% of our study population were illiterate compared to 25.9% with primary level education and 14.47% with secondary level education. However, we also recorded in this study that 1.63% of farm managers had completed higher education.

***Level of knowledge of pesticides***

The study revealed that of the 386 cashew nut growers, 68.9% (n=266) used chemical pesticides to maintain their orchards. However, 83.10% (n=221) of the latter had never been trained in the proper use of pesticides and on the risks incurred by the use of these synthetic products (67.6%).

***Level of pesticide use***

Figure 1 shows the means used by cashew nut producers to maintain plantations. Almost all producers (63.1%), in addition to mechanical maintenance (weeding), also used synthetic pesticides to control weeds and pests. But a minority of producers (2.5%) used exclusively pesticides to maintain their orchards in contrast to 33.8% of producers who practiced mechanical maintenance. However, producers from Mankono used pesticides since several years namely 6.94± 4.40 years while 4.10 ± 2.05 years for producers from Dabakala. The use of pesticides was recent in Bondoukou such as 2.25 ±1.04 years.

### Characterization of pesticides used in cashew tree cultivation

***Status of pesticides used in cashew tree cultivation***

The pesticides listed were mostly herbicides (74.28%) with 52 formulations, followed by insecticides (16

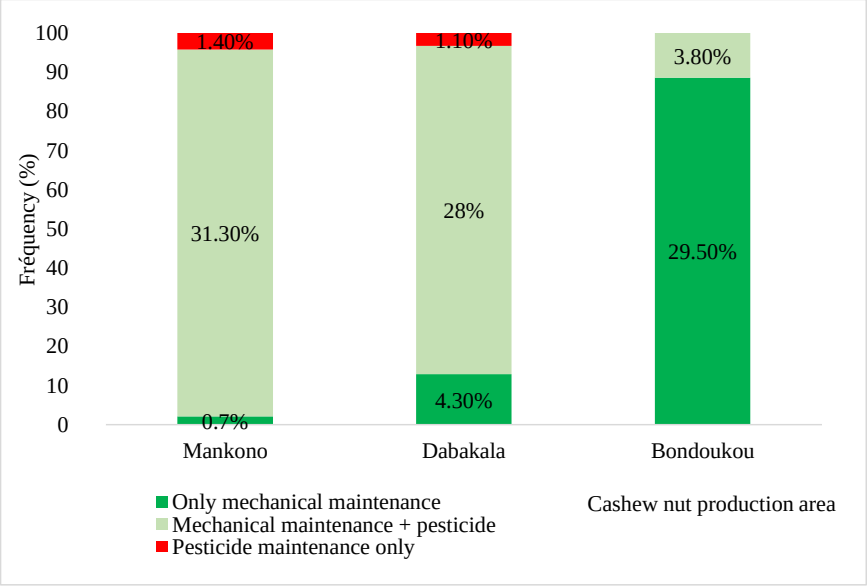


**Figure 1.** Distribution of producers according to the maintenance methods of cashew plantations.

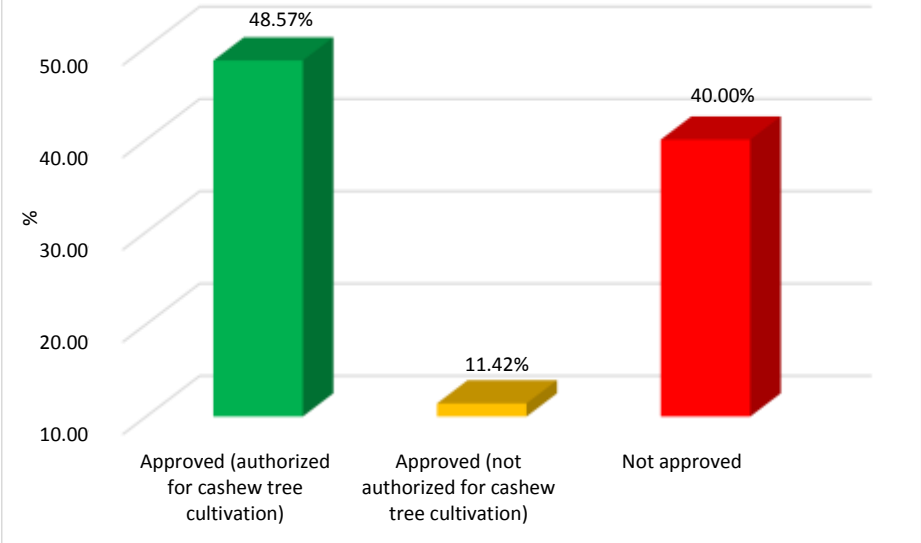


**Figure 2.** Pesticides used by registration status.

formulations), fungicides (1 formulation), fungicides/ fertilizer (1 formulation). In addition to this list, there were 32 pesticides that have not been formally identified. In total, 70 different specialties have been formally identified among producers across the three departments. From pesticides identified, 28 or 40% were not registered in Côte d'Ivoire (Figure 2). The different types of formulations encountered in the field were liquid (EC, SL) and solid (WG, SG) formulations.

### *Toxicity and frequency of use of pesticides in cashew tree cultivation*

Table 1 provided data on the active substances of chemical pesticides used in cashew nut plantations in

**Table 1.** Active substances identified among producers surveyed.

| S/N | Active components | Toxicity class | Chemicalsfamilies | Frequency of use (%) |
|---|---|---|---|---|
| | **Herbicides** | | | |
| 1 | Glyphosate | III | Phosphonoglycine | 75.1 |
| 2 | 2,4-D | II | Alkylchlorophenoxy | 13 |
| 3 | Paraquat | II | | 0.2 |
| | **Fungicides** | | | |
| *4* | *Mancozèbe* | *III* | *Carbamate* | 3.1 |
| *5* | *Metalaxyl-M* | *III* | *Phenylamide* | 0.2 |
| | **Insecticides** | | | |
| 6 | *Acétamipride* | *II* | *Neonicotinoid* | 4.2 |
| 7 | *Cyperméthrine* | *II* | *Pyrethroid* | 1.7 |
| 8 | *Profenofos* | *II* | *Organophosphorus* | 1.3 |
| 9 | *Lambdacyhalothrine* | *II* | *Pyrethroid* | 0.6 |
| 10 | *Deltamethrine* | *II* | *Pyrethroid* | 0.4 |
| 11 | *Imidaclopride* | *II* | *Neonicotinoid* | 0.2 |

II = Moderately dangerous; III = Slightly dangerous.

Mankono, Dabakala and Bondoukou. In this study, 11 active substances were identified, the most commonly used of which were "Glyphosate" followed by "2,4-D" with respectively 75.1 and 13% frequency of use by cashew nut producers. According to WHO acute toxicological classification, 9 actives substances were moderately dangerous (Class II) and 3 slightly dangerous (Class III). Toxic active substances (Class I) were not used by farmers interviewed.

## Level of compliance with safety recommendations in the use of pesticides

### *Timing of exposure to pesticides by cashew nut growers*

The survey revealed very different application times throughout the day. Thus, 14% of producers did it at any time of the day. But in all cases, they were most often done in the morning. Thus, our results revealed that 66% of applicators producers investigated, performed their treatments in the morning (6-10 am), 26% in the afternoon (1-4 pm) and only 12% in the evening (4-6 pm). Otherwise, the herbicides were more used among all pesticides found but their doses applied varied from one production area to another. Indeed, Mankono producers used an average of 10.6 L of herbicide per hectare while in the Dabakala and Bondoukou areas, the applied rates were 2.51 and 0.11 L per hectare respectively.

### *Frequency and duration of application of pesticides in cashew plantations*

Pesticides were usually applied 1-2 times in plantations during the agricultural year. However, the study revealed that 1.6 and 1.2% of producers applied herbicides and insecticides respectively 5 times during the agricultural year to better control speculative pests. The duration of exposure during the application of pesticides in 52.6% of cases varied between 2 and 4 h according to producers interviewed.

### *Data relating to accidents at work*

Figure 3 shows the different adverse effects of pesticides reported in the respondents. For example, 37.6% of applicators have revealed discomfort within 24 h after pesticide application.

### *Level of individual protection for producers*

The survey revealed that 36.8% of producers did not use Personal Protective Equipment (PPE) during pesticide applications. Only 0.4% of producer applicators were eligible for complete protection (Figure 4).

### *Management of pesticides packaging empty and remains by producers*

The majority of producers (61.10%) abandoned pesticide packaging in the wild. Rarely producers, only 1.8% of cases had the right reflex to return the packaging to the seller (Figure 5). In 14.4% of cases, these packages were used for other purposes. They were often used as gourds for producers and kitchen utensils (containing salt, milk,

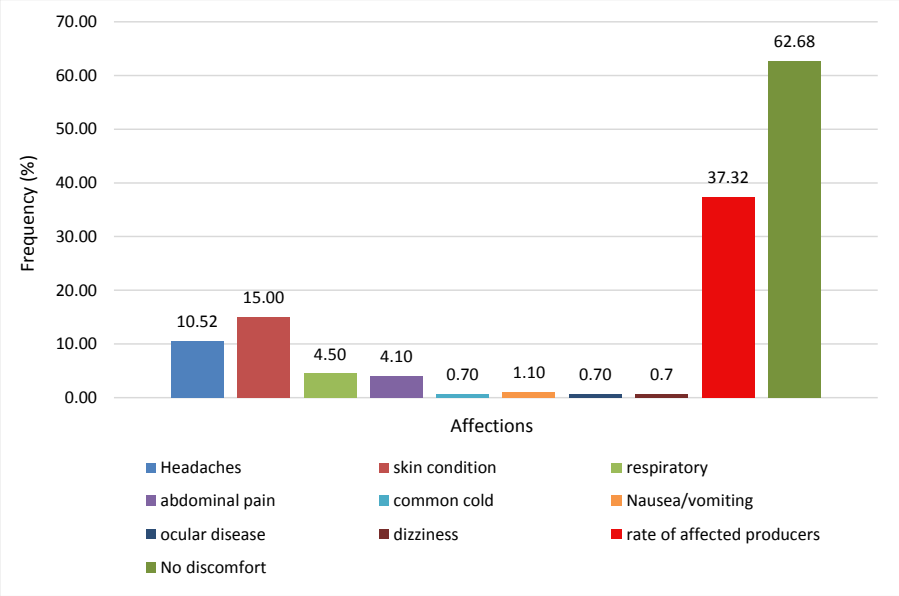


**Figure 3.** Acute poisonings reported by producers when using pesticides.

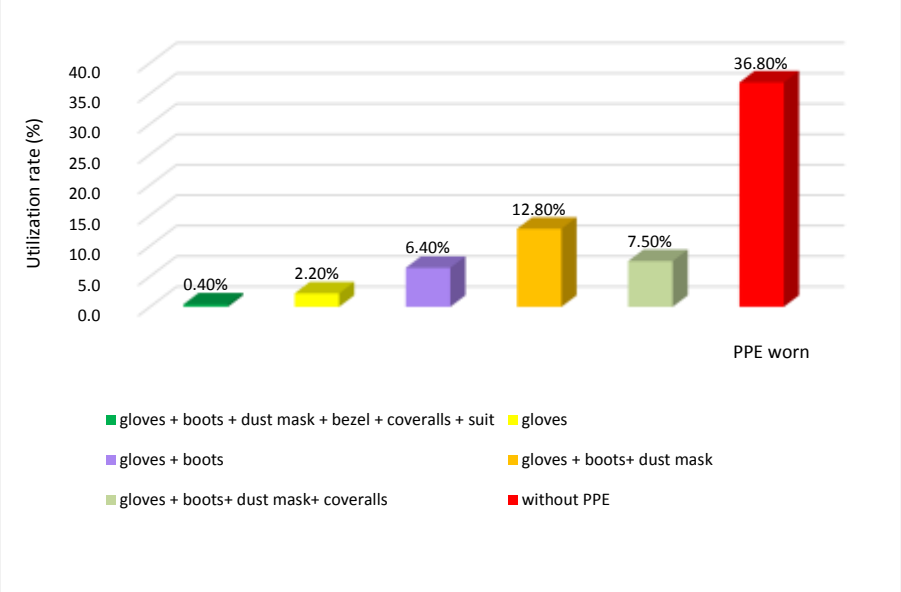


**Figure 4.** Set of personal protective equipment (PPE) worn by cashew nut producers.

oil, etc.) for wives producers in cashew tree fields.

## DISCUSSION

Our study focused on conditions of pesticides used in cashew plantations in Côte d'Ivoire aimed to evaluate level of sustainability requirements respect by growers. Indeed, crops such as coffee and cocoa were in certification process in Côte d'Ivoire. Cashew nuts are today a speculation abundantly produced and Côte d'Ivoire is the first producer and exporter in the world. So, the implementation of basis of certification appeared inevitable in cashew sector. We thought the improvement of cashew production should be accompanied by good agricultural practices about pesticides safety used in

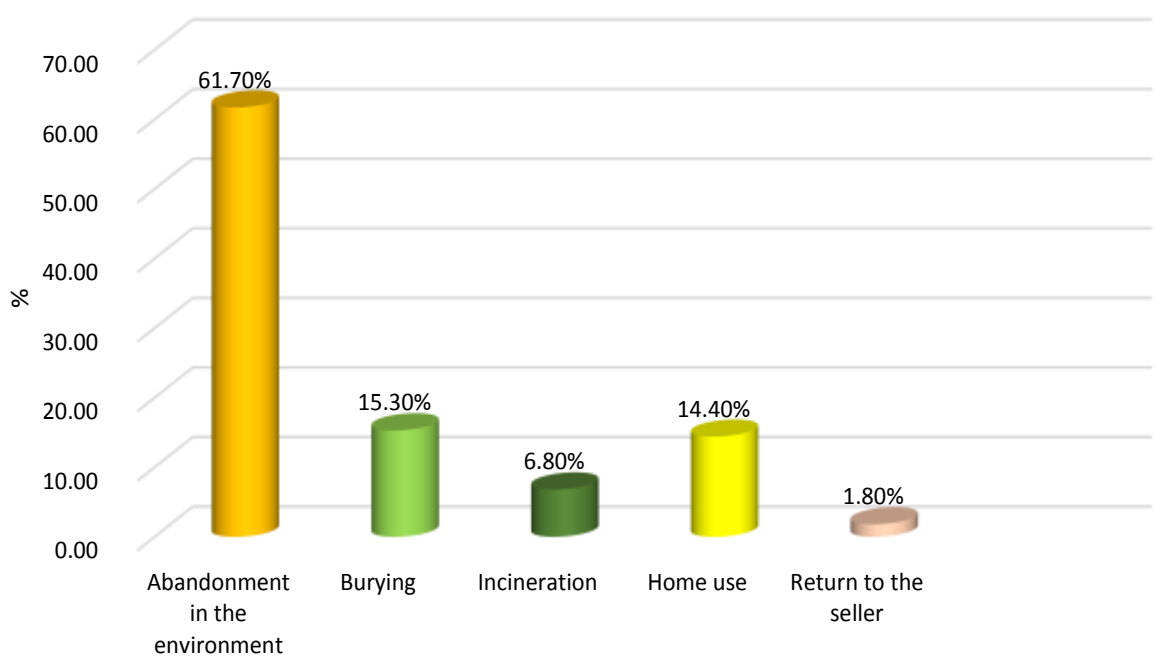


**Figure 5.** Type of management of pesticides empty packaging by producers.

order to mitigate occupational risks for pesticides users, to ensure cashew nuts safety and the preservation of the ecosystem. The variables studied in our study were socio-demographic aspects of growers, characteristics of pesticides and growers practices in pesticides use.

For the socio-demographic aspects, the average age of producers was 45 years but non negligible people had age over 50 years about 7.5% of total producers investigated (n = 386); the gender dominant was male (94%) and 66.0% of farmers were illiterate. Previous studies were available on socio-demographic aspects of cashew growers which confirmed our findings. It had been reported that cashew nuts productions occupied men, women and children in the world (Dorthe, 2003). In addition, more recent studies performed in Nigeria and Benin (western African countries) revealed that dominant gender of farmers was male with 88.3 and 83.3% respectively (Uwagboe et al*.,* 2010; Bello et al., 2017). The mean age of the Nigerian farmers was 49 years (Uwagboe et al*.,* 2010) which was sensitively similar to our results but under that reported from Benin with 59.81 years (Bello et al., 2017). Taken together, these findings indicated that more old people were involved in the production of cashew. About educational level, our results were similar to those reported from Nigeria (59%) of farmers interviewed (Uwagboe et al., 2010) but not as compared to those from Benin. Indeed, farmers from Benin who had some form of formal education were mainly in the primary and secondary school categories of 41.7 and 38.3% (Bello et al*.,* 2017) while our results revealed 25.9% at the primary and 14.47% at the secondary education level.

Concerning the characteristics of pesticides, despite 70 different specialties formally identified in the three departments with different levels of use, an analysis fin of active substances revealed 11 different molecules. Among pesticides identified, more of 50% were not homologated in Côte d'Ivoire as pesticides intended in cashew cultivation. The herbicides "Glyphosate" followed by "2,4-D" were more abundantly used with respectively 75.1 and 13% frequency of use. The acute toxicological profile of all 11 actives substances was moderately or slightly toxic according to WHO acute toxicological classification. The absence of pesticides bio-persistent such as organochlorine insecticides with their diversely biodegradation (Imran et al*.,* 2018) was an advantage for cashew sector in Côte d'Ivoire. But, the recent controversies about glyphosate in numerous countries should be posing some concerns.

However, despite the moderate toxicological profiles of pesticides identified, many practices of farmers and other factors could enhance their acute or chronic toxicity. Thus, numerous adverse effects had been reported within 24 h after pesticide application by 37.6% of applicators indicating acute toxicities. Among the symptoms identified, headaches, nausea, dizziness, colds, eye and skin disorders, respiratory disorders and abdominal pain were the most frequently cited by the farmers. Such adverse effects had been described when using herbicides during the arboriculture application

(Baldi et al., 2006; Lebailly et al., 2010). One explicative factor was the relative high age of farmers. Indeed, an aging hand for an activity as vigorousas agriculture would encourage the systematic use of herbicides for weed control with the consequences to favor duration and frequency of exposure. In addition, these people were more sensitive to the effects of pesticides because the functional capacity of certain vital organs and the xenobiotics metabolic capably decreased with age (e. g. kidneys) (Ouedraogo et al., 2016). The second factor concerned the very low level of education of cashew nut growers with an average of 64.48% illiteracy which was a limiting factor in understanding and applying the safety data on pesticide labels which, in sometimes cases (40%), were written in English and/ or in Chinese or unknown language. According to these producers, the choice of pesticides to apply would most often be based on approval from a producer who had already used them, information provided by itinerant pesticide dealers and, more rarely, on advertising spots. In doing so, they experimented with different plant protection products to control cashew nut pests. This confirmed the results that more than 63% of pesticide users relied on information obtained from their colleagues (Diop, 2013).

Other explicative factor could be the absence or deficiency of training on occupational risks related to pesticide use. Our study revealed that the majority of cashew nut producers (67.6%) had not received any training on occupational risks attributed to pesticides used. This did not conform to the International Code of Conduct on the Distribution and Use of Pesticides (FAO, 2011) and the law on pesticides in Côte d'Ivoire as inscribed in Decree No. 89-02 of 4 January 1989. This reality on the ground corroborated Melvin's results, which stated that most users of pesticides in agriculture had never received training in this regard (Melvin, 2000).

Moreover, the timing, doses and number of times of pesticides application could have toxic effects on farmers. Our study revealed that 26% of pesticides users performed in the afternoon (1pm - 4pm) and the duration of treatment varied between 2 and 4 h for 52.6% of producers interviewed. This could lead to the development of chronic diseases. It had been reported that exposure to solar radiation during herbicide application could be the cause of cancer development in most agricultural producers (Melvin, 2000) probably by mechanism of photo-toxicity which could be enhanced by absence or deficiency of protective personal equipment (PPE) (Diop, 2013). Our study revealed that only 0.4% of pesticides users were protected by complete PPE. But, the PPE used, were often rudimentary so they could not ensure protection that absolutely could predispose the applicator to high health risks (Rainaud, 2013; Gomgnimbou et al., 2009).

At last, the management of empty pesticide packaging should be improved in cashew sector in Côte d'Ivoire.

Our study revealed that 61.70% of applicators abandoned pesticide packaging in the wild by throwing it in the field or throwing it in unsecured places (holes, shallows). In 14.4% of cases, these packages were used for other purposes. They were often used as gourds for producers and kitchen utensils (containing salt, milk, oil, etc.) for wives producers. Rarely producers, only 1.8% of cases had the right reflex to return the packaging to the seller. The same practices had been previously described namely pesticide packaging were generally abandoned in the wild, buried or incinerated (Muliele et al., 2017; Tarnagda et al., 2017). There was an evident risk of environmental contamination (Camard and Magdelaine, 2010; Aïkpo et al., 2015). Moreover, the use of empty pesticides containers as gourds or salt, oil or milk containers could constitute a source of chronic exposure for the farmers' family because it is very difficult to eliminate all pesticide residues (Diop, 2013; Camard and Magdelaine, 2010). The incineration of packaging reported at 6.80% was not so risk-free for the producer. Indeed, during combustion, some pesticides produced highly toxic fumes whose inhalation or contact would be harmful to human and animal health (Congo, 2013).

## Conclusion

Our study allowed demonstrating that there was a disparity in pesticides use in the three main cashew cultivation areas in Côte d'Ivoire. The department of Mankono appeared the first user followed by Dabakala and to a lesser extent Bondoukou. There were high-risk farming practices in the use of pesticides characterized by a lack of knowledge of some pesticides used, non-compliance of with application rates, inappropriate wearing of protective clothing and, above all, poor management of pesticides packaging. With a view to sustainable agriculture with better protection of health and the environment through the rational and safety use of pesticides, it was necessary to define a coherent set of measures, including standards for sales, training and health and environmental monitoring. Our study should be deepened in order to clarify the real impact of pesticides uses on ecosystem and the consequences on cashew nuts quality namely nutritional and organoleptic aspects, moisture and mycotoxins subsequent and pesticides residues. Moreover, the incidence of chronic exposure of farmers and their family after both occupational and food exposure since pesticides containers were used as water gourds and kitchen utensils.

## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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