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**Research Article**

# SCREENING OF PHYTOSANITARY PRACTICES IN VEGETABLE GROWTH ACTIVITIESNORTHERN OF CÔTE D'IVOIRE

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**ABSTRACT**

The parasitical pressure in the market gardening, hugely affects the quality and quantity of vegetables production. To cope with that problem, the farmers use several pesticides varieties, which could have on one hand some consequences on the environment, and on the other hand on the heath of farmer and those of the consumers. To ensure a lasting production by following good practice, an analysis of phytosanitary practice has been performed in Korhogo (northern of Côte d'Ivoire), which is the greatest production zone of market garden crops. The said study was conducted through a survey done in 5 sites of market garden crop production in above mentioned locality according to 20 farmers per site. At the end of that evaluation we noticed that the most produced plants are cabbage, sorrel of guinea, eggplant, lettuces, okra, and chilli pepper. The study also showed that the most part of the used pesticide in the different sites were not appropriated for market garden plants since they were recommended for cotton crop. In addition there was not relationship between the multiple usages of pesticides and the diversity of vegetable growth plants and/or market garden crop yield. Finally, the present study sustained the possibility of a good phytosanitary practice (selective phytosanitary practice) in market gardening including diverse vegetable plants varieties.



## INTRODUCTION

Pesticides are used in the field of farming, of public health and that of veterinary medicine. They operate in the fight against insect pests and vector of plants disease and also in the anti-vectorial fight (against malaria particularly in the great urban centers) and for deparasitingectoparasite of animals (Fleischer *et al*., 1998). They contribute in improving the living conditions of population since some decades. However, in addition to their expensiveness, the use of pesticides in cultivation has many consequences, among which the most important are the toxicity towards human, the attack on the biodiversity, imbalance of the fauna and the resistance to the aimed target (Sougnabe *et al*., 2009). It moreover provokes the resistant insect's selection (Sougnabe *et al.* 2009). The use of non-authorized pesticides worsens the danger. Whatever the country, the use of phytosanitary products requires the respect of the usage precautions. In fact, the intoxication risks are never insignificant. Populations of developing countries, who are most of the time unlettered seem to be vulnerable than those of developed countries, in general sensible to the problem. In most of developing countries very few data exist on the real used pesticides. It is the case of the Côte d'Ivoire and particularly that of the commune of Korhogo. That commune of strong production of market garden crops, feeds the local market and the towns of the south in vegetable. The commune is otherwise located in the savannah where one of the main activities is the production of cotton. That farming requires an important use of pesticides. Beside this crop requires significant use of pesticides, in addition to its openness

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to Mali, Burkina Faso and Guinea, there are several types of pesticides on the market. The market gardeners have access to much kind of pesticides which the usage can be harmful for the users, for the consumer and for the environment. The purpose of that study is to evaluate the phytosanitary practices of market gardener in order to find and/or propose a solution to the lasting production respecting the environment. To reach this goal, we have registered (i) market garden crops produced in Korhogo locality; (ii) constantly used pesticides in that market garden farming and (iii) farmers applying pesticide methods.

## MATERIAL AND METHODS

***Experimental site***: The present study was conducted in the commune of Korhogo, situated between latitude 8°26 and 10°27 North and longitude 5°17 and 6°19 West. This commune is at 600 Km from Abidjan (Northern of Côte d'Ivoire). It belongs to the Sudano-Sahelian dry tropical climatic regime whose seasonal rhythm is regulated by the displacement of the Intertropical Front (Jourda *et al.*, 2005). That climate is characterized by two seasons. The rainy season from May to October with a maximum raining in September and the dry season from November to April, characterized by the Harmattan which comes from December to February. The average annual pluviometry varies between 1100 and 1600 mn with an average annual temperature varying also between 25 and 35°C (Kouakou *et al.*, 2012). There is many shallows in that commune, constantly water where are market garden crops farmed. Thus, to carry that study we conducted a survey near 100 farmers spread in the market garden crops production sites of the dam of Kokoh, of Sinistré, of Kabolo, of Natio and of Logokaha (Fig 1).

In each site, 20 farmers were questioned. Like Wognin *et al.* (2013), the questionnaire submitted to the farmers regards identity, sex, nationality and ethnic group parameter as well as the level of education , the grown plants, the entomologic problems faced, the fighting methods, the kind of pesticide, the using way, the supply source and the health problems link to the usage of pesticides.

***Statitical analysis***: Multivariate statistical analysis based on our previous developed pipeline (Dago *et al.,* 2016) has been achieved establishing a relationship between analyzed experimental sites and grown vegetables varieties. Descriptive statistical analyses were performed assessing grow vegetable crops variance as well as dispersion in the five (5) processed experimental sites. Qualitative data that indicated right and/or wrong usage of pesticide were transformed in numeric with R software function "*as.numeric"*, in "zero" (0) indicating wrong and/or in "one" (1) specifying correct phytosanitary practice in each considered and analyzed experimental site. Moreover, statistical analysis performed in this study based on R updated version (version 3.3.1) software as providing numerous updated scripts and functions for data representation as well as providing quick and well-established analytical statistic test (R Core team, 2013).

## RESULTS

### *Pesticides Applying Way and Health Problem*

The present analysis evidenced that the market gardeners of the study zone are all women. They are all Ivoirians and belong to the Senoufo ethnic group (autochthon population). They are aged from 40 to 55. In fact, 95 % of that analyzed population resulted to be unschooled and 5% has first cycle level.

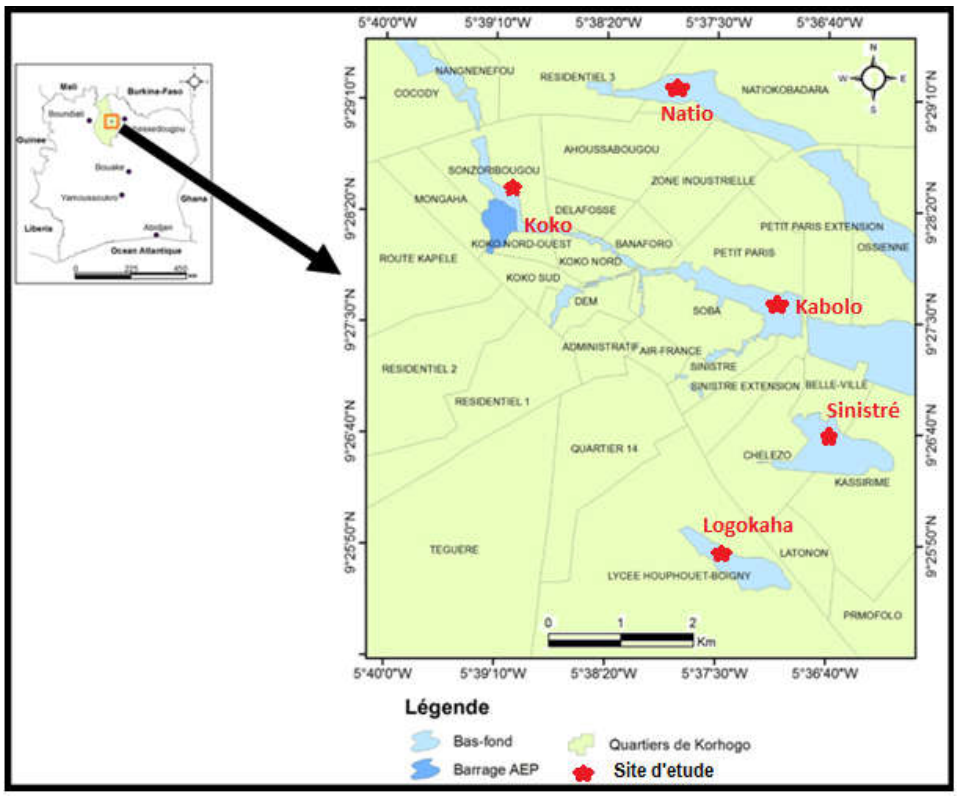


**Figure 1** Map of Korhogo locality illustrating the five (5) analyzed and processed experimental studied sites.

On the whole, the majority of farmers do not use device to spread the pesticides over the plants. In 100 farmers only 22; (22%) used devices against 78% who use buckets and brooms (traditional practice) (Fig 2A). In the site of Sinistré, only 15% of farmers use a device against 85% who do not use devices. In Kabolo site, 95% of farmers do not use adequate devices. The same analysis suggested that in both Logokaha and Natio experimental sites, all the met farmers do not use devices (Figure 2B).On the other hand, in Koko, 90% of farmers use devices (Fig 2). However, the present survey hypothesized good farmer practices *vis-à-vis* of Koko experimental site, since 90% of farmer from that site use correctly devices as opposed to Sinistré, Logokaha, Natio and Kabolo sites. Considering as a whole this analysis revealed traditional practice way vis-a-vis of pesticides usage northern of Cote d'Ivoire (Fig 2).

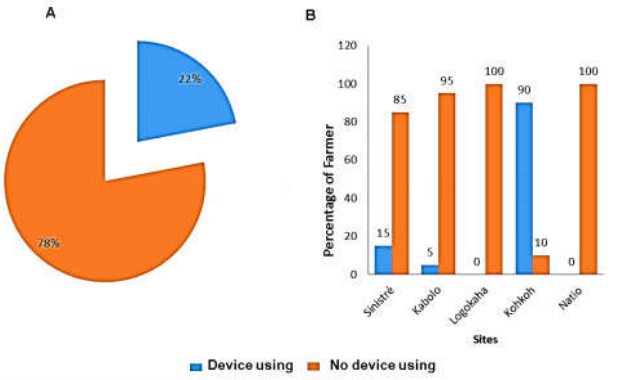


**Figure 2** (A) Summary of pesticide application method. (B) Pesticide application method by processed and/or analyzed experimental site.

### *Relationship Analysis between Grown Vegetables and Processed Crop Sites*

Our analysis showed a similitude between the all analyzed experimental sites in term of grown vegetable average, that ranged from 3.44 to 3.94 (Table 1). The same observation has been done considering processed vegetable variety number (Table 1). However, the present analysis suggested both "Kabolo" and "Logokaha" experimental sites as relatively more solicited than those of Sinistré, Barrage_Koko and Natio site in term of vegetable yield. Also, Logokaha and Barrage_Koko sites exhibited high variance values with respect to the other analysed experimental sites, suspecting a high diversity of vegetable grown activity in these experimental sites (Table 1). Moreover, our results proposed Barrage_Koko experimental site as relatively less solicited for vegetable crops. However, performing vegetable dispersion analysis by processing the five analysed experimental sites, we showed an agreement between (i) Sinistré, Kabolo and Barage_Koko sites as well as between (ii) Natio and Logokaha sites (Fig 3A). This survey also proposed all analyzed experimental site as potentially suitable for vegetable crops activity, suggesting high variance and/or variability between processed vegetables plant variety (Fig 3A). In addition, the same analysis suggested the high recurrence of cabbage in the present analysed experimental sites (Fig 3B). Taking together, this survey evoked similitude between processed sites in term of compactness of grown vegetables showing some variance difference referring to processed vegetables diversity as well as distribution.

**Table 1** Descriptive statistics of processed vegetables (cropped vegetable activity) according to analyzed experimental sites

| | Sinistré | Kabolo | Logokaha | Barrage_Koko | Natio |
|---|---|---|---|---|---|
| ¼ Quartile | 0.75 | 1.5 | 1 | 0 | 0 |
| ¾ Quartile | 5 | 6 | 4.5 | 3.25 | 4.75 |
| Mean | 3.44 | 3.94 | 3.62 | 3.12 | 3.25 |
| Variance | 15.06 | 18.60 | 22.12 | 23.32 | 17.80 |
| Standard Deviation | 3.88 | 4.31 | 4.70 | 4.83 | 4.22 |
| Vegetable type number | 12 | 12 | 13 | 11 | 11 |

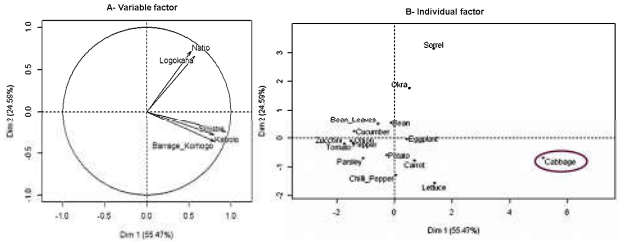


**Figure 3** Multifactorial analysis linking analyzed experimental site (Variable Factor) and varieties of grown vegetable (Individual Factor).

### *Pearson Correlation Survey Assessing Experimental site Concordance and/or Discordance Weighing Grown Vegetable Varieties*

Pearson correlation analysis (Table 2) showed a high agreement between Sinistré and Barrage-Koko experimental sites in term of grown vegetable types (p-value<0.01). The same observation exhibited a good concordance between both Kabolo and Sinistre experimental sites (p-value<0.001). Multivariate statistical analysis by box plot graph, suggested cabbage as the most cropped vegetable (Fig 4). Moreover, our analysis recorded sorrel, eggplant (aubergine), okra and chilli-papper vegetables as the most grown, assuming analysed plants yield average as benchmark (see Fig 4). Interestingly, Sinistre, Barrage-Koko and Kabolo experimental sites exhibited the highest cabbage production. Furthermore, previous mentioned sites displayed a comparable chilli-pepper production. Finally, our analysis recorded comparable production of eggplant and okra vegetables in both Sinistre and Kabolo sites. Basing on these results and observations we suspected cabbage, chilli-pepper, eggplant and okra vegetables as favouring the consistent correlation between both (i) Sinistré and Barrage-Koko and (ii) between both Kabolo and Sinistre experimental sites (Table 2 and Fig 4). Also, a relative high agreement (p-value<0.05) has been observed between Barrage-Koko and Kabolo sites as well as between Natio and Logokaha experimental sites (Table 2). These results supposed chilli-pepper, sorrel and cabbage as potential factors supporting that agreement, since exhibiting comparative production value processing the formers experimental sites (Table 2). Taking together, this survey showed several score of concordance and/or discordance (Pearson correlation analysis) between analysed experimental sites, proposing chilli-pepper, cabbage, eggplants, sorrel and okra as recurrent processed and cropped vegetables.

### *Descriptive Statistical Analysis of Pesticides Used in Vegetable Crops Activities in Processed Experimental Sites*

Next, we analysed the relationship between processed experiment site and the proportion of pesticide practice referred to vegetable crops activity.

**Table 2** Pearson correlation analysis measuring grown sites agreement assessing vegetables varieties

| | Sinistre | Kabolo | Logokaha | Barrage_Koko |
|---|---|---|---|---|
| Kabolo | 0.78*** | | | |
| Logokaha | 0.35* | 0.22* | | |
| Barrage_Koko | 0.84*** | 0.53** | 0.28* | |
| Natio | 0.33* | 0.25* | 0.56** | 0.13* |

***p-value<0.001, **p-value<0.05 and *p-value<0.1.

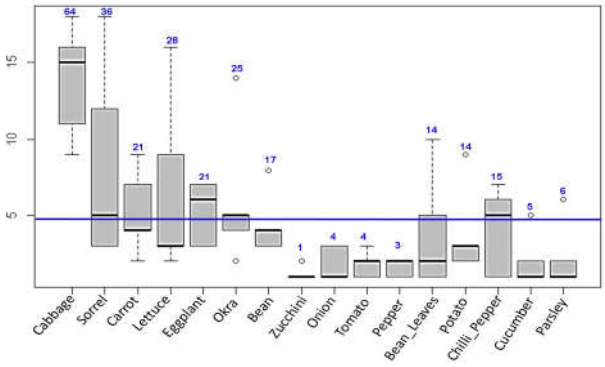


**Figure 4** Multivariate statistical survey via a boxlot analysis assessing grown vegetable proportion as well as variance parameter (variability) in Sinistré, Koko, Logokaha, Natio and Kabolo experimental sites.

Our analysis revealed discordance between number of used pesticide and number of processed vegetable variety. Indeed, Barrage-Koko experiment site exhibited a high number of cropped vegetable although using a small amount as well as a reduced number of pesticide category (Table 1 and 3). Also, the present analysis suggested both Barrage-Koko and Natio experimental sites as least affected by pesticide practice as opposed to those of Logokaha. The same analysis indexed Sinistre and Kabolo experimental site as being relatively influenced by the pesticide custom. However, proportion analysis referring to the pesticide practice revealed Logokaha (14 different pesticides), Kabolo (7 different pesticides) and Sinistré (6 different pesticides) as sites allowing high pesticide practice as opposed to those of Barrage-Koko and Natio (Table 3). Also, Euclidian distance of Pearson correlation analysis displayed short distance and/or high concordance between (i) Sinistré and Kabolo sites as well as between (ii) Barrage-Koko and Natio experimental site excluding Logokaha

**Table 3** Descriptive statistics survey describing pesticides usage in the five (5) analysed experimental sites.

| | Sinistré | Kabolo | Logokaha | Barrage_Koko | Natio |
|---|---|---|---|---|---|
| ¼ Quartile | 0.00 | 0.00 | 0.50 | 0.00 | 0.00 |
| ¾ Quartile | 1.00 | 1.00 | 1.00 | 0.00 | 0.00 |
| Mean | 1.21 | 1.47 | 1.16 | 0.95 | 0.63 |
| Minimum | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Maximum | 15 | 15 | 5 | 14 | 7 |
| Unique Number of Pesticides Used in Analyzed Vegetable Crops Activities | 6 | 7 | 14 | 4 | 4 |

present result (Table 3) with those reported in Table 1, our findings suggested Barrage-Koko and Natio experimental sites as suitable processing highest variety of vegetable crops by using a reduce number and/or selective pesticides category. Considering as a whole these results evoked right vegetable grown activities reducing disproportionate usage of pesticide.

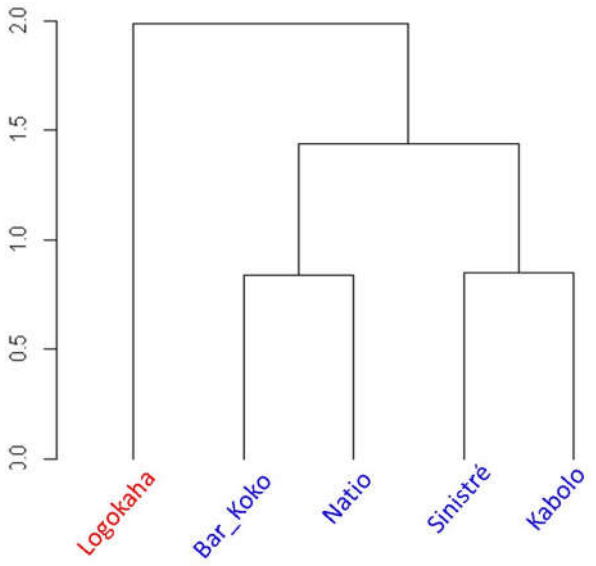


**Figure 5** Euclidian distance of Pearson correlation assessing similitude and/or dissimilitude among Logokaha, Koko, Natio, Sinistré and Kabolo experimental sites in term of selective phytosanitary practice in vegetable crops activities.

### *Relationship Analysis between Grown Vegetables and Pesticide Practice Proportion*

The present analysis exhibited all analysed territories as involved in pesticide practice assessing vegetable crops activity. However, our findings suggested different behaviour of Logokaha experimental site with respect to the other's one evaluating pesticide usage ratio (Figure 6A). This result was in agreement with the previous one (Figure 5). Also, multi factors analysis displayed *Thian* pesticides as the most solicited in the present processed vegetable grown activity (Figure 6B). However, our analysis proposed famers from experimental site of Barrage-Koko as exhibiting good pesticide practice as opposed to the others processed and/or analysed sites (Table 3).Indeed, 90% of farmers that operated in this area have been detected as to rightly used pesticide in their vegetable grown activities. Also, this analysis proposed Kabolo, Logokaha and Natio experimental sites as strongly influenced by the wrong practice of pesticide usage in vegetable crops activities (p-value <0.05). The same survey suggested a relative good practice of pesticide in vegetable grown in Sinistré site as opposed than those of Kabolo, Logokaha and Natio (p-value<0.05). Then, difference observed between Logokaha and Barrage-Koko as well as Sinistré experimental site (Fig 6 and Table 4) can be attributed at the right and/or wrong phytosanitary practice in vegetable crops activity. Further, this survey established Barage-Koko as the best site in term of vegetable crop activities since exhibiting a high variety of vegetable by using a reduce number of pesticide suggesting a right phytosanitary practices (Tables 3 and 4). Finally, our findings excluded definitively Logokaha as an exemplar vegetable crops site (Table 3 and 4; Fig 5 and Fig 6). Taking together, the present results showed disproportionate phytosanitary practice in processed experimental sites, and proposed Barage-Koko site as goodly coordinate both growth vegetable yield and pesticide practice in comparison with the other's analysed experimental sites.

**Table 4** Descriptive statistic evaluating right and/or wrong usage of phytosanitary practice in vegetable crow activities northern of Cote d'Ivoire

| | Sinistré | | Kabolo | | Logokaha | | Barrage_Koko | | Natio | |
|---|---|---|---|---|---|---|---|---|---|---|
| | R_Used | W_Used | R_Used | W_Used | R_Used | W_Used | R_Used | W_Used | R_Used | W_Used |
| Famers Proportion (%) | 0.20 | 0.80 | 0.05 | 0.95 | 0.00 | 1.00 | 0.90 | 0.10 | 0.00 | 1.00 |
| Variance | 0.17 | 0.17 | 0.05 | 0.22 | 0.00 | 0.00 | 0.09 | 0.09 | 0.00 | 0.00 |
| Standard Deviation | 0.41 | 0.41 | 0.05 | 0.22 | 0.00 | 0.00 | 0.31 | 0.31 | 0.00 | 0.00 |
| Famers Number | 3 | 17 | 1 | 19 | 0 | 20 | 18 | 2 | 0 | 20 |

R: Right and W: Wrong

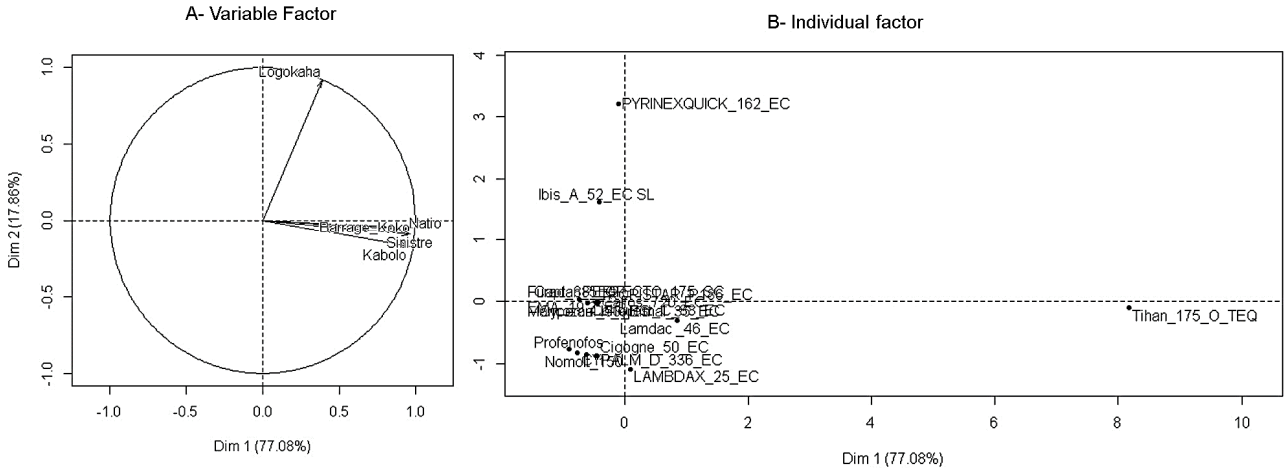


**Figure 6** Multifactorial principal component survey associating analyzed experimental site (Variable Factor) and phytosanitary practice (Individual Factor).

## DISCUSSION

Several studies and Scientifics rapport suggested the strong impact of parasitical pressure vis-à-vis of agricultural yield. Then, northern region of Cote d'Ivoire don't escape to that tendency. We performed a phytosanitary screening analysis in five different experimental sites in Korhogo locality northern of Cote d'Ivoire (Fig1). The present study included native population exclusively with a discrete instruction level. Our finds evidenced that farmers in Korhogo locality do not use pesticide sprayers or protective devices (Fig 2). In addition, they do not also respect the latter recommended doses. Indeed, according to Doumbia and Kwodjo (2009), in the suburbs of Abidjan, market gardeners use pesticides recommended for vegetable crops and respect more or less the recommended doses because of the sporadic visits they receive from local agents of the National Agency for Rural Development Support (ANADER), intern students and no governmental organization (NGO), unlike those in Abidjan. Our findings revealed that 90% of farmer operating in Koko experimental site use appliances. This results could be supported by the fact that producers and/or farmers of this experimental site claimed receiving training about the risk of pesticide use (Fig 2). Moreover, the present analysis showed that vegetables yielded in Korhogoarea are diversified and dominated by cabbage, sorrel, killi pepper, okra and eggplant (Figs 3 and 4). That diversification could be explained by the high demand of the market (Kanda *et al*., 2014).

In fact, the population of Korhogo is much diversified causing existence of diverse eating habit. That situation is seen in the market by a diversity of the demand. In addition plants produced in such sites are intended to other markets such as According to Wognin and al. (20013), crops produced in Abidjan are leaf vegetable (lettuce, spinach and mint), fruit vegetable (okra, eggplant, chilli, zucchini, cucumber and pepper) and bulb vegetable (onion, garlic and leek). However, the present study suggested all processed and/or analyzed experimental sites (the five examined experimental sites) as suitable for vegetable crops activities (Fig 3A) reinforcing vegetable crops activities northern of Cote d'Ivoire (in Korhogo). In addition cabbage, sorrel, egg plant and okra and chilli-pepper discriminated as most cropped vegetable in Korhogo were suspected to cluster presently processed experimental site in two different groups (Fig 3 and Table 1). Relationship analysis between the five (5) processed experiment sites and the proportion of pesticide practice referred to vegetable crops activity revealed discordance between both multitude pesticide usage and growth vegetable variety number. In addition, our findings proposed Barrage-Koko experiment site as displaying a high number of cropped vegetable although using a small amount as well as a reduced number of pesticide category (Table 1 and 3). Indeed, the performance of this site in term of good synergy between pesticide practice and vegetable crop activity, could be attributed to didactic instruction received by the farmers of that site as previously mentioned. Also, the present analysis evoked both Barrage-Koko and Natio experimental sites as slightest solicited by pesticide practice as opposed to those of Logokaha. In the same propensity both Sinistre and Kabolo experimental sites claimed to be relatively influenced by the pesticide custom. Then, Euclidian distance of Pearson correlation analysis suggested high concordance between both (i) Sinistre and Kabolo and both (ii) Barrage-Koko and Natio experimental site excluding Logokaha as pesticide free environment (Fig 5 and Table 3). In other words, famers for Logokaha experimental site have been recorded as unscrupulous users of pesticide practice as opposed to the the other's analysed

experimental site. Furthermore, our findings suggested Barrage-Koko and Natio experimental sites as suitable area processing highest variety of vegetable crops by using a reduce number of pesticides category evoking right vegetable grown activities reducing disproportionate usage of pesticide (Table 1 and 3). However, pesticides used in vegetable growth activities in Korhogo fighting insect pest are diversified (Fig 6B).That high diversity could be explained by easy access of farmers to all kinds of products. In fact, this area belongs to high production zones of cotton which uses high quantity of pesticide. In 1995, cotton accounted for 62.1% of insecticide consumption (Fleischer *et al*., 1998). In addition, Korhogo district, bordered Mali and Burkina Faso. The porosity of our borders stressed by the crisis years has encouraged the entry of many pesticides from these countries. That diversity of pesticides in vegetable crops could also be explained by the weak instruction level of farmers, since 95% of interviewed farmers are illiterate. According to Ahouangninou *et al*, 2011; the high diversity of pesticides in vegetable production is due to the fact that the farmers do not benefit from any supervision or continuous training. They just buy in the local market the pesticides without knowing nor the toxicity either the using way. All the used pesticides are not in the majority for vegetables (Doumbia and Kwadjo, 2009). In fact, our survey revealed a high proportion of wrong usage of phytosanitary practice in vegetable grow activities in all processed experimental sites except in those of Koko, where 90% of famer population have been discriminated as right user of phytosanitary practice (Table 4). These results suggested that famer supervision and/or continuous training can strongly contribute helping good phytosanitary practices in the presently analyzed area (Doumbia and Kwadjo, 2009). Generally processed farmers in processed experimental site are looking for products that are available, effective and less expensive. A high proportion of farmers do not benefit from training on the risk of non-homologous pesticide use, given the parasitic pressure and market demand, farmers prefer cotton pesticides that are very persistent, effective and less expensive. Then, as previously suggested, the majority of producers and/or famers are not lettered. Indeed, only 5% of these populations have a level of the first primary cycle. These results are close to those obtained by Ahouangninou *et al* (2011). According to their observations, farmers do not apply prescribed doses because they cannot read, with literacy rates of 57%. In the same tendency our finding discriminated high frequency of Thian_175_OTeq pesticide (a cotton pesticide) usage and has excluded Logkaha experimental site as suitable for good phytosanitary practice (Fig 6). So the present survey advised that failure to comply with good phytosanitary practices could be due to farmer ignorance vis-à-vis of right phytosanitary practice. According to a study carried out in Abidjan, 73.4% of producers are not aware of the risks of contamination due to their behavior, compared with 8.3% who claim to acknowledge their responsibility for the contamination of vegetable products (Wognin *et al*., 2013). Moreover, the poor phytosanitary practice linked to the low literacy rate of vegetable farmers is not a fate. Indeed, the good practices observed in the suburbs of Abidjan, which are constantly being visited by ANADER agents and students as well as the site of Koko where illiterate farmers have received training are some example. In addition, the producers met during this study in the commune of Korhogo are all women. This could be explained by the fact that men coming from villages to look for job have wives who are not well qualified for town Work. To make themselves useful, they set up shallows to produce vegetables, to feed their family and buy what their need. This sector is also occupied by women who have lost their husbands or who have been dismissed by their husbands. These results are different from those obtained by Wognin *et al*. (2013). According to these authors, the market gardening of the city of Abidjan is practiced at 77.98% by men and 22.02% by women.

## CONCLUSION

At the end of this study, it appears that in Korhogo, several types of vegetable are produced. The most important are cabbage and guinea sorrel, chilli pepper, eggplant and okra. To this diversity of vegetables is associated the variability of the type of pesticides dominate by those non-authorized for vegetable farming. Moreover, it is clear from this study that the bad phytosanitary practices recorded in the different analyzed experimental sites would not be justified by the diversity of vegetable crops, but by the ignorance of these users. Therefore, the present study has sustained that an awareness of producers on the good phytosanitary practices could contribute to guarantee not only diversity in the production of market gardening products but also to preserve the environment and health of farmers as well as of population.

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