



(RESEARCH ARTICLE)



Pesticides used on the cultivation of *Brassica oleraceae var capitata* L. (cabbage) in the Niayes area (Senegal): Impact on the environment and the health of producers

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Abstract

The Niayes area, by its climate and its morpho-pedology, is a favorite area for market gardening in Senegal. For vegetables, it is accredited to more than 60% of harvests. Among the cultivated speculations is the cabbage (*Brassica oleraceae var capitata* L.). With a view to alleviating the negative effect of pests, a variety of pesticides are used by producers. This study was undertaken with a view to contribute to a better knowledge of the pesticides used in the production of Cabbage (*Brassica Oleracea*) in the Niayes. Specifically, it aims to characterize the pesticides used in the area and to determine their impacts on the environment and the health of producers. To carry out this study, a survey was carried out among 163 cabbage producers in the Niayes area (Mboro and Diogo) from February 06 to March 03, 2018. The data entry and processing of the results were made thanks to the Epi info software and Excel spreadsheet. The results showed that 87.1% of producers use chemicals. At the end of this study, 24 active ingredients, mainly comprising four (4) major chemical families, were identified. The most widely used pesticides are insecticides, insecticides-acaricides-nematicides and herbicides with respectively 56%, 12% and 11% of citations. Profenofos is the most cited active ingredient with 21.1% followed by emamectin benzoate with 14%, pendimethalin (12%) and carbofuran (11%). In addition, Organophosphates and Amino-Phosphates are the most representative chemical families with 48% and 15% citations, respectively. Among the producers; 85.9% have already suffered from poisoning from the use of pesticides. 43% of producers reported the death of insects and other animals as a result of the treatments.

Keywords: *Brassica oleraceae* L; Impact; Environment; Health; Producers; Senegal

1. Introduction

In Senegal, horticulture has rapidly evolved over the past decades. Horticultural production estimated at 905,000 tonnes in 2012 increased to 1,446,360 tonnes of fruits and vegetables in 2018 [1]. Among the crops grown in Senegal, cabbage (*Brassica oleracea*) ranks fifth in national vegetable production and constitutes nearly 8% of vegetable production volumes [2]. In fact, between the years 1999, 2011 and 2017, the areas sown to cabbage fell respectively from 1454 ha, 2444 ha to 4648 ha while production rose from 22,582 tonnes, 45,000 tonnes [6] to 73,116 tonnes in 2017 [3]. Despite this upward trend, market gardening production of this vegetable is limited by abiotic and biotic factors including pests and weeds which affect the resulting yields. Pest pressure has been identified as the major constraint due to crop losses inflicted on market gardeners ([11]; [14]). Thus, the fight started is essentially focused on the use of chemical treatments based on synthetic pesticides. Most of the studies carried out on cabbage cultivation in Senegal have generally focused on pests ([18]; [12]) and on the value chain [16]. However, few studies focusing on the diagnosis of phytosanitary practices have been carried out. In addition, this chemical control, which had presented very positive results in terms of increasing agricultural yields from its appearance in the 1940s [19], is currently the subject

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of several controversies because of many cases of resistance to these products and their negative impacts on human health and the environment. This study was undertaken in the Niayes area in order to contribute to a better knowledge of the pesticides used in the production of Cabbage (*Brassica Oleracea*).

Specifically, it aims to characterize the pesticides used in the area and to determine their impacts on the environment and the health of the producers.

2. Methodology

2.1. Presentation of the study area

The studies were carried out in the Niayes area more precisely at the level of three market gardening unions in Mboro and Diogo made up of producer groups. Mboro is a small coastal town in northwestern Senegal, located in the coastal section; the great coast 25 km west of Tivaouane and 117 km north of Dakar at geographical coordinates 15 ° 09 'North, 16 ° 54' West.

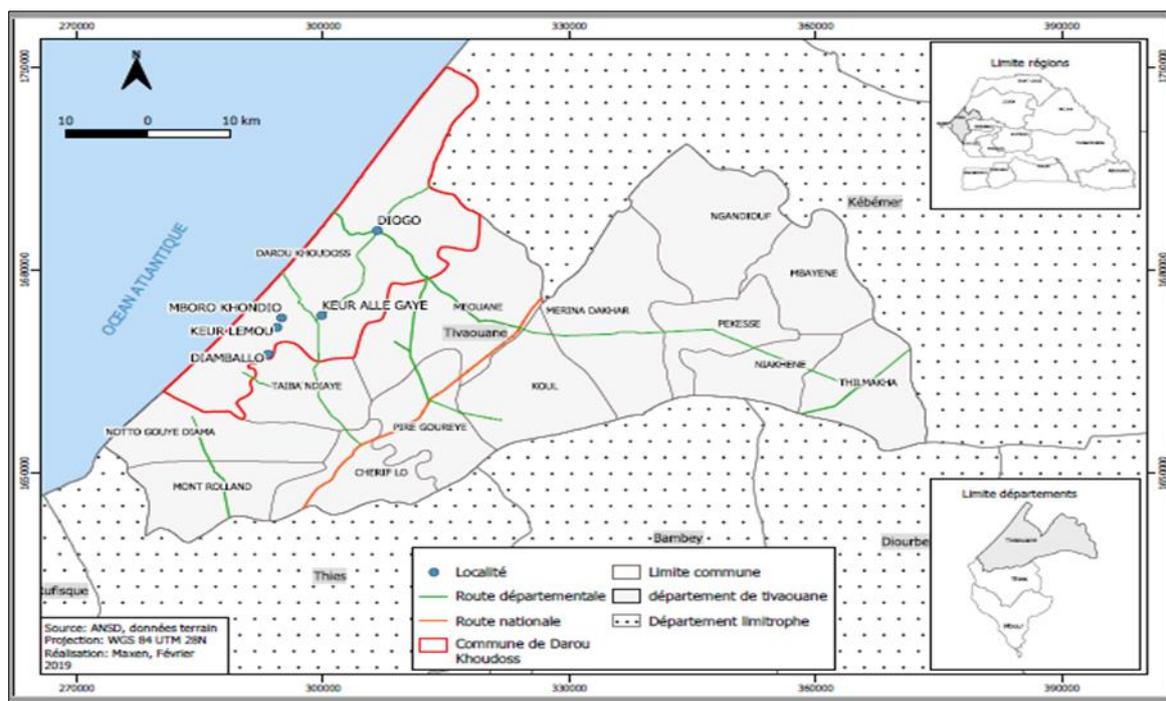


Figure 1 Geographical location of Tivaouane

2.2. Sampling

The stratified sampling method we have used consists of subdividing a heterogeneous target population of size N into k strata of more homogeneous size n.

It involved three (3) unions of cabbage producers including two (2) located in the Mboro area and one (1) in Diogo. The unions are divided into groups including four (4) located in the Mboro area, specifically in the villages of: Keur Allé Gaye (KAG), Khondio (KH), Keur Lemou (KL), Diamballo (DM) and a Diogo group (DG) in the Diogo area.

The size of this sample in each area was obtained from the following (Danielli, 1998) formula:

$$n = U^2 \left(1 - \frac{\alpha}{2}\right) P \frac{(1 - P)}{d^2}$$

n = sample size, $U^2 (1 - \alpha / 2) = Z$ distribution, $Z = 1.96$

P = estimated proportion of the population exhibiting the characteristic cabbage producer;

d = fixed margin of error, fixed d = 10%.

The size of the sample obtained n is then distributed in proportion to the size of the population in each group according to the formula:

$$Ne = ni / N * n$$

Ne = number of market gardeners to be surveyed, ni = number of market gardeners constituting the group

N = total number of market gardeners in the selected groups, n = sample size.

A total of 163 farms distributed among producer groups were visited.

2.3. Collection of data

Within each village, random sampling was applied by scanning the cabbage farms in the area until the number retained by the sampling was reached.

The questionnaire was thus filled immediately following a semi-structured interview in the middle of the field with the owner or, failing that, the agricultural employee. It provides information on phytosanitary practices and the impacts of pesticides on the health of the applicators and on the environment through the death of animal species not targeted by the treatments. Then additional work consisting in identifying the active ingredients of the pesticides mentioned was done with the local sellers of the products in each group. The pesticide families, targets and hazard classes according to the World Health Organization (WHO) of pesticides were determined using the existing documentation.

2.4. Processing of survey data

The information collected during the survey was analyzed manually, then entered and analyzed using the Epi Info 7 software and the Excel spreadsheet.

The citation frequencies (CF) were calculated from the following formula:

$$CF\% = Nc / N * 100$$

Nc = number of citations of a variable and N = number of citations at the site level.

3. Results and discussion

3.1. Diagnosis of phytosanitary practices

According to the results of the survey, 87.1% of market gardeners only use chemicals to control pests and weeds, 12.3% additionally use organic products and only 0.6% use only organic products.

The results of Table 1 show that 24 active materials belonging to 10 chemical families were identified.

The most frequently used organophosphate active ingredients are: profenofos, haloxyfop-R-methyl and medamidophos with respective citation frequencies of 21.1%, 11.7% and 7.3%.

The active ingredient of the amino phosphate family used is emamectin benzoate with 14.6%.

For dinitroanilines, pendimethalin is the active ingredient used but was only mentioned in keur Alla Gaye and Diogo with successively 1.4% and 17.7%.

For carbamates and dithiocarbamates, methomyl and maneb are the active ingredients which were cited with successively 10.7% and 0.5% of the respondents.

The distribution of pesticides according to target (figure 2) shows a dominance of products intended to eliminate insects which then represent 56% of products which target all insects, mites and nematodes with (12%) and products that target herbs (11%).

The pesticides used in the cultivation of cabbage (figure 3) belong to four (4) major chemical families which are: organophosphates (OP), amino-phosphates (AP), carbamates and dithiocarbamates (Carb and Dithio), and dinitroanilines (Din).

According to the WHO classification, most of the pesticides used in the Niayes area (Figure 3) are moderately dangerous substances (class II), and represent more than 50% of all the products listed.

The results obtained showed that 85.9% of the producers surveyed declared that they had already suffered from poisoning following the use of pesticides (Figure 4). Table 2 shows the signs of poisoning observed after spraying pesticides.

Table 1 Active ingredients and families of identified pesticides

Families	Active ingredients	KAG		KH		KL		DM		DG		Total	
		Nc	FC	Nc	FC	Nc	FC	Nc	FC	Nc	FC	Nc	FC
Aph	Emamectine benzoate	5	6.8	7	11.5	4	28.6	2	5	66	17.1	84	14.6
Aver	Abamectine	8	10.8	5	8.2	-	-	4	10	12	3.1	29	5.1
AP	Acetamipride- cypermerthrine	-	-	-	-	-	-	-	-	1	0.3	1	0.2
	Profenofos -cypermethrine	-	-	1	1.6	-	-	-	-	-	-	1	0.2
	Lambdacyhalothrine -acetamipride	8	10.8	6	9.8	-	-	-	-	5	1.3	19	3.3
	Cypermethrine -acetamipride -profenofos	-	-	2	3.3	-	-	-	-	-	00	2	0.3
	Profenofos- cypermethrine	-	-	-	-	-	-	-	-	1	0.3	1	0.2
Chlor	Imidaclopride	-	-	2	3.3	-	-	-	-	-	-	2	0.3
Din	Pendimethaline	1	1.4	-	-	-	-	-	-	68	17.7	69	12
Org	Glyphosate	4	5.4	1	1.6	-	-	-	-	-	-	5	0.9
	Haloxyfop-R-methyl	-	-	1	1.6	1	7.1	-	-	65	16.9	67	11.7
	Profenofos	20	27	17	27.9	6	42.9	13	32.5	65	16.9	121	21.1
	Dimethoate	12	16.2	2	3.3	-	-	4	10	9	2.3	27	4.7
	Ethotrophos	-	-	3	4.9	-	-	2	5	-	-	5	0.9
	phenitrothion	1	1.4	1	1.6	-	-	-	-	-	-	2	0.3
	Malathion	-	-	-	-	-	-	-	-	1	0.3	1	0.2
	Metamidophos	8	10,8	3	4.9	-	-	-	-	31	8.1	42	7.3
	Trifloxystrobin Triadimefonp	1	1.4	-	-	-	-	-	-	-	-	1	0.2
	Phentoate	-	-	-	-	-	-	-	-	2	0.5	2	0.3
Orgchl	Dicofol	-	-	1	1.6	2	14.3	3	7.5	6	1.6	12	2.1
Carb Dithio	Carbofuran	4	5.4	3	4.9	1	7.1	6	15	49	12.7	63	11
	Methomyl	-	-	3	4.9	-	-	5	12.5	2	0.5	10	10.7
	Maneb	-	-	1	1.6	-	-	-	-	2	0.5	3	0.5
Inog	Soufre micronisé	2	2.7	2	3.3	-	-	1	2.5	-	-	5	0.9

Ph: Amino-phosphates, Aver: Avermectins, AP: Combination of Pesticides Chlor: Chlornicotiniles; Din: Dinitroanilines; Organic, Org: Organophosphates, Orgchlor: Organochlorines; Carb and dithio: Carbamates and dithiocarbamates Keur Allé Gaye (KAG), KHondio (KH), Keur Lemou (KL), Diamballo (DM) et Diogo (DG).

Analysis of this table 2 shows that the symptoms most frequently encountered in market gardeners in our entire study area were overall: fatigue (29.4%), headaches (19%) and dizziness (14.9%).

Among the market gardeners surveyed, 43% declared that they had already observed the deaths of other insects or animals other than pests after the treatment.

The results presented in Table 2 showed that the birds were by far the most affected during the treatments with 78.6% of citations.

Table 2 Declared intoxication symptoms

Symptoms	KAG		KH		KL		DM		DG		Total	
	Nc	FC%	Nc	FC%	Nc	FC%	Nc	FC%	Nc	FC%	Nc	FC%
Eye irritation	6	12.8	2	5.9	-	-	1	2.3	-	-	9	3.1
Skin irritation	7	14.9	2	5.9	1	10	3	7	8	5.2	21	7.3
Tired	13	27.7	8	23.5	2	20	9	20.9	53	34.2	85	29.4
Vertigo	3	6.4	3	8.8	1	10	5	11.6	31	20	43	14.9
Cough	2	4.3	2	5.9	1	10	7	16.3	13	8.4	25	8.7
Diarrhea	2	4.3	3	8.8	-	-	-	-	-	-	5	1.7
Headache	10	21.3	9	26.5	2	20	9	20.9	25	16.1	55	19
Vomiting	-	-	1	2.9	2	20	4	9.3	8	5.2	15	5.2
Irritation of the nose	4	8.5	-	-	-	-	1	2.3	1	0.7	6	2.1
Difficulty breathing	-	-	3	8.8	-	-	3	7	7	4.5	13	4.5
Fever	-	-	1	2.9	1	10	1	2.3	9	5.8	12	4.2

Table 3 Animal species declared dead following treatment

Species	Nc	FC%
Donkey	2	2.8
Spider	1	1.4
Goats	1	1.4
Locusts	4	5.7
Ants	3	4.3
Flies	3	4.3
Birds	55	78.6
Butterflies	1	1.4
Total	70	100

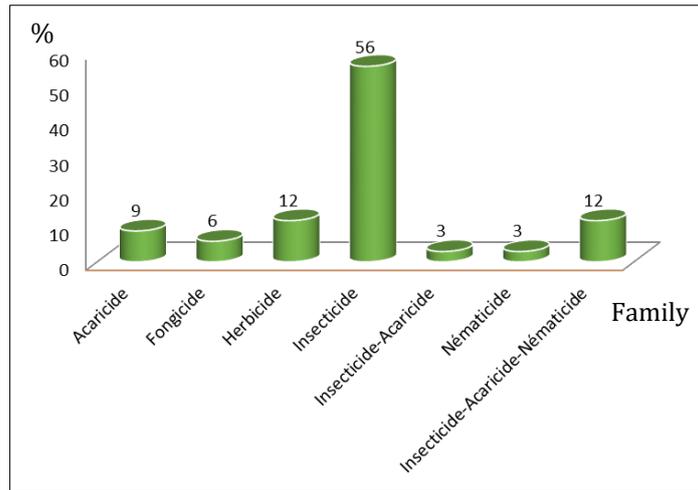


Figure 2 Distribution of pesticides by family

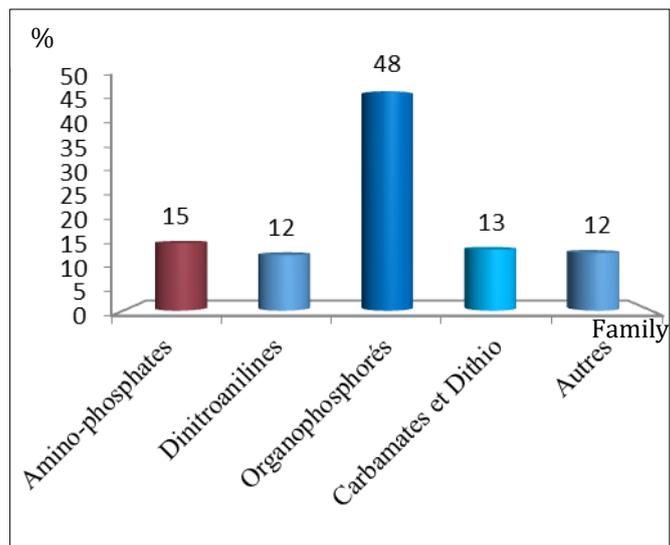


Figure 3 Distribution of pesticides according to chemical family

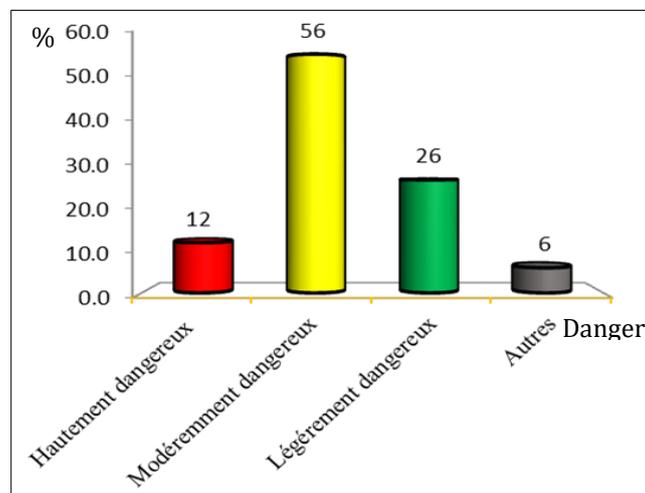


Figure 4 Distribution of pesticides according to the level of danger

4. Discussion

In the study area, the application of pesticides was the main method of controlling pests. The majority of producers surveyed, 87.1%, declared that they only use chemical substances. These results corroborate those of [4] in Dakar region where 77.38% of producers use pesticides in their horticultural stations.

This situation could be explained by the availability of large quantities of chemicals in the informal market, the sensitivity to attacks of market garden products, the perception of the potential risk of yield losses, but also by the absence of an effective and available management alternative immediate pest.

A total of 24 active substances belonging to organophosphates, amino-phosphates, carbamates and dithiocarbamates and dinitroanilines were identified. This same number of active ingredients was listed in southern Benin by [1]. Profenofos was the most cited active ingredient with 21.1% followed by emamectin benzoate with 14% pendimethalin (12%) and carbofuran (11%).

Insecticides were the most widely represented pesticides. These results are similar to those of James, DH, Pimentel CSP, Ahouangninou *et al.* Four (4) herbicides (Glyphosate, Aligator and Haloxyp-R-methyl) were found among the molecules mentioned. However, these two previously cited authors did not identify any herbicides in the cited molecules. In Cameroon, 29 molecules including herbicides, fungicides and insecticides have been applied to tomato crops [10].

Organophosphorus active ingredients are the most cited (48%) compared to other families. These results are in line with those of [12] in the Niayes area of Dakar where organophosphates were the most used pesticides with 62.3%. In addition, the use of organophosphates is worldwide important because of their low cost, their broad spectrum of activity and their low persistence in the environment.

Compared to the work of [20] and [17] in the Niayes area, these results reveal the appearance of two families of pesticides, the aminophosphates and dinitroanilines.

Most of the pesticides listed (56%) belong to WHO class II (moderately dangerous). However, four (4) pesticides belonging to class IB (Tamron, metafos, furadan and lannate) represent 12% of the pesticides listed. These results do not corroborate those reported from Botswana by [11] where nearly a third of the active ingredients used by farmers were classified as extremely or highly dangerous. Among the 24 active ingredients identified, only 10 are approved by the Sahelian Committee of Pesticides [3]. Four (4) active ingredients are prohibited from use (dicofol, metamidophos, carbofuran and malathion) due to their persistence in the environment and their toxicity for humans and animals.

The results also showed that 85.9% of producers have already suffered from poisoning from the use of pesticides. This is different from the results obtained by [17] where more than 50% of the producers surveyed in the Niayes area of Mboro declared that they did not suffer from any harm after the treatments. The most frequently cited symptoms were fatigue (29.4%), headache (19%) and dizziness (14.9%). Frequent contact with the most unauthorized products and the lack of wearing full protective equipment as well as non-compliance with treatment times (early in the morning or late in the evening) can cause the appearance of these recurring symptoms among producers.

For the impact on animal species, 43% of producers had reported insect and animal deaths following treatments, including the most cited birds with 78%. These results are in line with those of [20] in the Niayes area where 30% of market gardeners had observed the action of the products they use in the environment and the species cited as an indicator were bird deaths and other species not targeted by the treatments.

5. Conclusion

The most common means of control among producers of *Brassica oleracea* (cabbage) in the Niayes zone is mainly chemical control. At the end of this study, 24 active ingredients, mainly comprising four (4) major chemical families, were identified. The most widely used pesticides are insecticides, insecticides-acaricides-nematicides and herbicides with respectively 56%, 12% and 11% of citations. Profenofos is the most cited active ingredient with 21.1% followed by emamectin benzoate with 14% pendimethalin (12%) and carbofuran (11%). In addition, Organophosphates and Amino-Phosphates are the most representative chemical families with 48% and 15% citations, respectively. 85.9% of producers have already suffered from poisoning from the use of pesticides. For the impact on animal species, 43% of producers reported animal species deaths following treatment.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare no conflict of interest.

References

- [1] SENEGALAISE EXPORT PROMOTION AGENCY. Horticulture: Continuation of the upward trend in horticultural production in Senegal. 2018.
- [2] DIRECTORATE OF HORTICULTURE (DH). Evolution of productions and areas sown with cabbage in 2006 and 2011 in Senegal. 2011.
- [3] FAOSTAT. Agriculture data. Food and Agriculture Organisation. United Nation. 2017.
- [4] Ahouangninou C, Martin T, Assogba-Komlan F, Cledjo P, Kpenavoun Chogou S, Nouatin G, Boko W, Soumanou MM, Houssou C, Biau G. Assessment of the sustainability of vegetable production in southern Benin. CBRST Notebooks. 2015; 2: 98–126.
- [5] CSP. Global list of pesticides authorized by the Sahelian pesticides committee. 2019.
- [6] Ornamental plants of the city of Dakar: characterization of the flora, key to determining taxa and photo library. Master memory. 2014; 162.
- [7] DIRECTORATE OF HORTICULTURE (DH). Production and areas sown with cabbage in Senegal. 1999.
- [8] FAO. International Code of Conduct on the Distribution and Use of Pesticides, Revised Version adopted by the Hundred and Twenty-third Session of the FAO Council in. November 2002; 35.
- [9] James B, et al. Integrated pest management in vegetable production: a guide for extension workers in West Africa. Ibadan, Nigeria: IITA. 2010.
- [10] G Matthews, T Wiles, P Baleguel. «A survey of pesticide application in Cameroon,» *Crop Prot.*, n°22. 2003; 707-714.
- [11] Kanda M, Akpavi S, Wala K. Diversity of cultivated species and production constraints in market gardening in Togo. *Int. J. Biol. Chem. Sci.* 2014; 8 (1): 115-127.
- [12] Labou B, Bordat D, Brevault T, Diarra K. Importance of "Cabbage moth" in the Niayes in Senegal: interrelations with temperature and cultivars used. *International Journal of Biological and Chemical Sciences.* 2016; 10: 706–721.
- [13] Mondédji AD. Potential for the use of extracts of neem leaves (*Azadirachta indica* A. Juss) and *Carica papaya* L.) the control of insect pests of cabbage (*Brassica oleracea* L.) in urban and peri-urban areas in southern Togo. Doctoral thesis, University of Lomé, Togo. 2010; 193.
- [14] Mondédji AD, et al. Analysis of some aspects of the vegetable production system and producers' perception of the use of botanical extracts in the management of insect pests of vegetable crops in southern Togo. *Int. J. Biol. Chem. Sci.* 2015; 9 (1): 98-107.
- [15] Pimentel D, Humer MS, Lagro JA, Efroymson RA, Landers JC, Mervis N, McCarthy CA, Boyd AE. Benefits and risks of genetic engineering in agriculture. *BioScience.* 1989; 39: 606-614.
- [16] Sakho SM. Head cabbage (*Brassica oleracea*) value chain analysis in the Niayes area of Senegal. Master's thesis in Agrobusiness and Development of value chains. National Higher School of Agriculture-ENSA, Thiès, Senegal. 2013; 63.
- [17] Sene M. Pesticide use practices and residue levels in horticultural products in the Niayes de Mboro area: possible effects on public health. Pharmacy thesis, Dakar: UCAD. 2008.
- [18] Sow G. Integrated population management of *Plutella xylostella* L. (Lepidoptera: Plutellidae), the main pest of cabbage in Senegal. Thesis in Animal Biology. Entomology specialty. UCAD: Dakar. 2013; 181.

- [19] Van Der Werf HM. Evaluate the impact of pesticides on the environment. *The INRA Environment Courier*. 1997; 31: 5–22.
- [20] Wade CS. The use of pesticides in peri-urban agriculture and its impact on the environment. University of Cheikh Anta Diop, Dakar. 2003; 55.