



RESEARCH ARTICLE

PESTICIDE RESIDUE CONTAMINATION OF VEGETABLES: A CASE STUDY OF THE FÉLIX HOUPHOUËT-BOIGNY INTERNATIONAL AIRPORT MARKET GARDENING AREA (CÔTE D'IVOIRE)

¹Gnagne Agness Essoh Jean Eudes Yves*, ²Aka Camille, ³Seka Yapoga Jean, ⁴Coulibaly Djenebou Wagnidanhan, ⁴Traoré Satou and ⁴Ballet Tiama Guy

¹Laboratory of Thermodynamics and Physicochemistry of the Environment, Nangui Abrogoua University, Abidjan, Côte d'Ivoire; ²Oceanologic Research Center, Côte d'Ivoire; ³Institute of Agropastoral Management (IGA), Peleforo Gon Coulibaly University of Korhogo, Korhogo, Côte d'Ivoire; ⁴Laboratory of Environmental Sciences, Nangui Abrogoua University, Abidjan, Côte d'Ivoire

ARTICLE INFO

Article History:

Received 20th June, 2026

Received in revised form

25th July, 2026

Accepted 16th August, 2026

Published online 30th September, 2026

Keywords:

Contamination; Plant Protection Products;
Lambda-Cyhalothrin; Acetamiprid;
Lactuca Sativa; Chives.

*Corresponding author:

Gnagne Agness Essoh Jean Eudes Yves

ABSTRACT

Urban vegetable farming is expanding rapidly and often relies on the intensive use of plant protection products to improve yields, raising public health concerns. This study assessed residues of two commonly used insecticides, lambda-cyhalothrin and acetamiprid, in *Lactuca sativa* and *Allium schoenoprasum* leaves (chives). Analyses were performed by high-performance liquid chromatography with UV detection, and the measured concentrations were compared with the Codex Alimentarius Maximum Residue Limits (MRLs). The results showed that all concentrations were below the MRLs, confirming the compliance of the samples with food safety standards. However, the Kruskal–Wallis and Mann–Whitney tests, together with Principal Component Analysis, revealed significantly greater accumulation in *Allium schoenoprasum* leaves. This difference is associated with the physicochemical properties of the compounds, application frequency, and leaf morphology. These findings support targeted monitoring and further assessment of chronic dietary exposure risks.

Copyright©2026, Gnagne Agness Essoh Jean Eudes Yves et al. 2026. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Citation: Gnagne Agness Essoh Jean Eudes Yves, Aka Camille, Seka Yapoga Jean, Coulibaly Djenebou Wagnidanhan, Traoré Satou and Ballet Tiama Guy. 2026. "Pesticide Residue Contamination of Vegetables: A Case Study of the Félix Houphouët-Boigny International Airport Market Gardening Area (Côte d'Ivoire)". *International Journal of Current Research*, 18, (09), 38297-38303.

INTRODUCTION

Rapid urbanization generates numerous challenges, particularly in terms of food supply and employment opportunities (Bricas *et al.*, 2004). The Abidjan district, as a metropolis, attracts populations of diverse origins, primarily motivated by the search for stable employment in the structured or formal sector (Antoine and Coulibaly, 1989). However, the massive influx of migrants, both national and foreign, contributes to rising urban unemployment and the growing number of laid-off workers. Faced with these challenges, the most vulnerable urban populations turn to urban and peri-urban agriculture, particularly market gardening, to meet their needs. This type of agriculture plays an increasingly important role in supplying cities with food, particularly vegetables (Dieye, 2006; Pham 2006; Hmida-Sayari, 2005; Dongmo *et al.*, 2005; Midmore *et al.*, 2005). Urban market gardening is an intensive activity that relies heavily on the use of plant protection products to increase yields (Kpan *et al.*, 2019; Tano *et al.*, 2011). A study conducted in the perimeter of Félix Houphouët-Boigny

International Airport (Abidjan district) by Coulibaly (2020) revealed that market gardeners primarily use insecticides (95%), fungicides (70%), herbicides (25%), nematicides (16.7%), and acaricides (6.7%). Among these products, insecticides based on Lambda-cyhalothrin + acetamiprid and chlorpyrifos-ethyl are the most widespread. Approximately 37% of market gardeners in this area use the insecticide K-Optimal, whose active ingredient is Lambda-cyhalothrin + acetamiprid (Coulibaly, 2020). The study by Agueh *et al.*, (2015) shows that 82.4% of market gardeners at the Houéyiho market gardening site in Benin use Lambda-cyhalothrin-based products to combat pests. In Côte d'Ivoire, in the locality of Daloa, market gardening follows this same principle of using plant protection products throughout the production chain (Kouamé *et al.*, 2025). In general, market garden producers make use of plant protection products. This situation raises concerns about the sanitary quality of the cultivated vegetables, which are intended for both local consumption and export. However, these products must comply with international standards to ensure safe and healthy consumption. In this context, the present study aims to assess the level of

contamination of two widely consumed species, *Lactuca sativa* L. (*Lactuca sativa*) and *Allium schoenoprasum* L. (*Allium schoenoprasum* leaf or chive), by plant protection product residues.

MATERIALS AND METHODS

Study Area

Location: The Abidjan metropolitan area is located in southeastern Côte d'Ivoire, between latitudes 5°00' and 5°30' N and longitudes 3°50' and 4°10' W. It covers an area of 57,735 ha and comprises ten municipalities. As the country's largest urban center, it exemplifies the rapid demographic growth experienced by Côte d'Ivoire, with an estimated population of 6,187,795 inhabitants [13].

The municipality of Port-Bouët is located in the southern part of the Autonomous District of Abidjan. It covers an area of approximately 110 km² on the narrow strip of land separating the Ebrié Lagoon from the Atlantic Ocean. It is bounded to the north by the Ebrié Lagoon, to the south by the Atlantic Ocean, and to the west by the municipality of Yopougon.

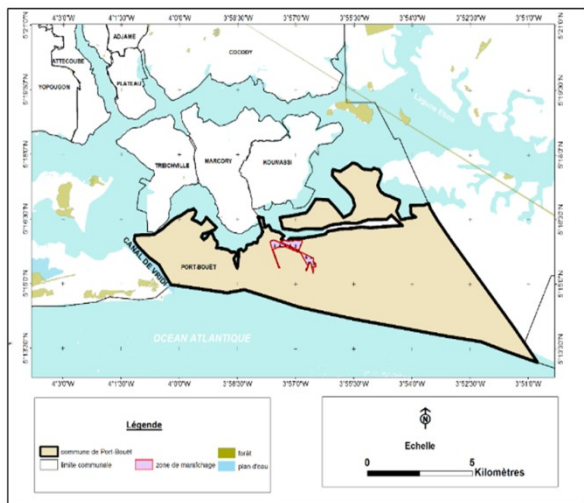


Fig 1. Location of the Municipality of Port-Bouët

Physical Characteristics: The present study was conducted at a vegetable production site located in the municipality of Port-Bouët, between the Ébrié Lagoon, the Félix Houphouët-Boigny International Airport, and the Thomas d'Aquin Ouattara Camp (formerly the French military camp of the 43rd Marine Infantry Battalion, 43rd BIMA). Commonly referred to as the 43rd BIMA belt, this area is a permanently waterlogged wetland that provides favorable conditions for year-round vegetable cultivation.

Monthly rainfall ranges from 26 mm in January to 610 mm in June, while the average air temperature remains relatively constant throughout the year at approximately 27°C. Furthermore, the Port-Bouët vegetable production site is the largest market gardening area in the Abidjan District. It is located in the eastern part of the Port-Bouët municipality, between 5°16'00" N and 3°57'30" W (Figure 2).

Study Material: The study material consisted of *Lactuca sativa* and *Allium schoenoprasum* cultivated at the study site.

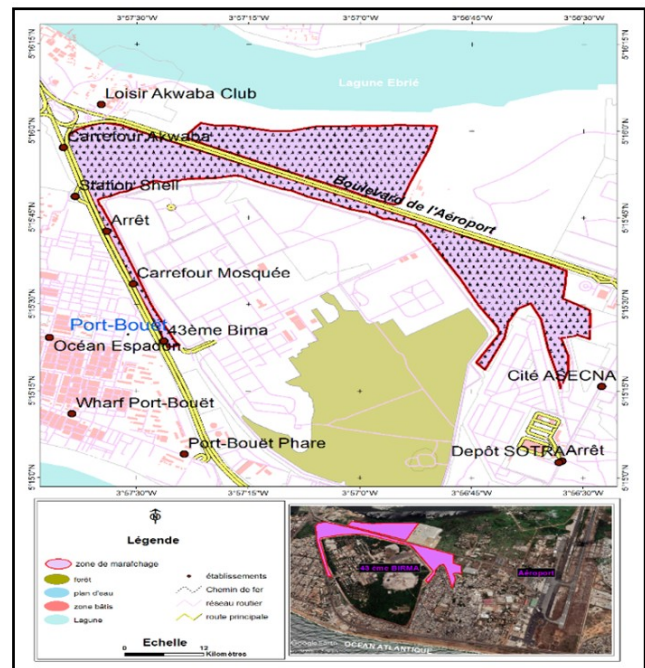


Fig 2. Map of the vegetable production areas in Port-Bouët

Sampling

Collection of *Allium schoenoprasum* and *Lactuca sativa*



Fig 3. Vegetable crops: *Lactuca sativa* and *Allium schoenoprasum*

To assess the levels of pesticide contamination in vegetable crops, a targeted sampling approach was conducted on two vegetables commonly consumed by local populations: *Allium schoenoprasum* and *Lactuca sativa*. Samples were collected and purchased directly from three vegetable production sites (Table 1). These sites were selected based on their high agricultural activity and geographical distance from each other to ensure adequate spatial representativeness. Sampling was carried out on Tuesday, April 29, 2025, between 08:00 and 10:30 a.m. For each vegetable species, three (03) composite samples were prepared from five (05) plots randomly selected at each site. On each plot, five (05) mature plant units were collected according to the sampling protocol illustrated in Figure 4.

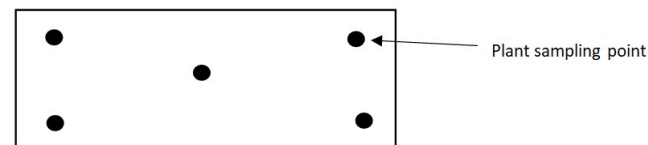


Figure 4. Sampling scheme for market garden produce samples within a bed

The five sub-samples obtained in this way were pooled to form a composite sample. From this mixture, an average sample of 1 kg was taken per product type.

The samples were then packaged in food-grade bags with a capacity of three (03) litres, in order to prevent secondary contamination and limit the photodegradation of pesticide residues. Each bag was labelled, placed in a cooler at 4 °C, and then transported to the laboratory of the Centre de Recherches Océanographiques (CRO) for analysis.

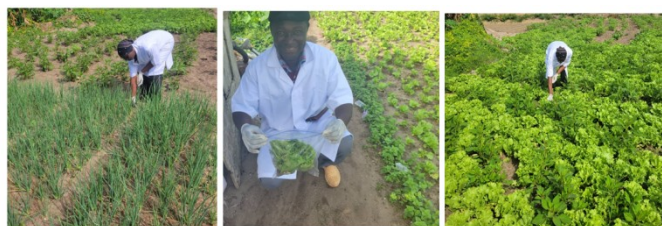


Figure 5. Sampling and packaging of samples in food-grade bags

Sampling of the phytosanitary product: K-Optimal insecticide

Choice of pesticides: The study conducted by Coulibaly (2020) was used as a reference for selecting the active substance to be analysed. Given the diversity of pesticides available and their varying degrees of toxicity, it was important to assess the level of contamination of market garden produce. Accordingly, the active ingredient most widely used within the insecticide class (lambda-cyhalothrin + acetamiprid) was targeted. As this substance accounts for more than 35.1% of the pesticides used in the study area, its quantification provides a reasonably representative measure of the contamination level of market garden produce. For pesticide residue analysis, sampling focused on the insecticide K-Optimal, whose active substances are Lambda-Cyhalothrin (15 g/L) and Acetamiprid (20 g/L), formulated as an emulsifiable concentrate (EC). The product was purchased directly from licensed vendors operating at the various market gardening production sites.

Sample Analysis

Extraction Procedure: Upon arrival at the laboratory, each sample was cleaned to remove stems and other impurities, and then homogenized using a mortar until a uniform paste was obtained. A 10 g aliquot of the homogenized sample was weighed into a beaker, and 50 mL of double-distilled water was added. The mixture was thoroughly homogenized and subsequently filtered through Whatman filter paper. The resulting filtrate was transferred into a separatory funnel, to which 50 mL of dichloromethane was added. The mixture was vigorously shaken and then allowed to stand until complete phase separation was achieved. The organic phase (lower layer; Figure 6), containing the lipophilic compounds, was collected in a 500 mL round-bottom flask. The dichloromethane extraction was repeated three consecutive times to maximize extraction efficiency. The three organic extracts were combined and filtered again through Whatman filter paper into a ground-glass round-bottom flask. Finally, the solvent was evaporated to dryness using a rotary evaporator maintained at a constant temperature of 40 °C.

Sample Cleanup: For sample cleanup, the C18 solid-phase extraction (SPE) cartridge was first conditioned with 10 mL of methanol. The concentrated sample extract was then passed through the C18 cartridge. After complete drying of the cartridge, the retained pesticides were eluted from the C18 sorbent. Subsequently, 5 mL of methanol was added to the



Figure 6. Separatory Funnel Used for Liquid–Liquid Extraction

round-bottom flask containing the residue obtained after solvent evaporation. The solution was filtered through a 0.45 µm membrane disc filter into a test tube. The resulting filtrate was transferred into an HPLC vial using a Pasteur pipette for pesticide quantification by high-performance liquid chromatography (HPLC) (Shimadzu).

Data Processing and Statistical Analysis: The data obtained from the analyses of vegetable samples and plant protection products were processed using Microsoft Excel and Statistica 7.0 software. Statistical analyses included correlation tests and non-parametric tests.

RESULTS AND DISCUSSION

RESULTS

Nature of the insecticide used: The chromatogram obtained by high-performance liquid chromatography (HPLC) coupled with ultraviolet detection at 254 nm enabled the identification and quantification of the active ingredients lambda-cyhalothrin and acetamiprid. These active compounds were detected in the analyzed K-Optimal EC insecticide sample at retention times of 3.58 min and 2.78 min, respectively (Figures 7 and 8). The retention time corresponds to the time required for a compound to elute from the chromatographic column and reach the detector. The signal amplitude of 700 millivolts (mV) indicates a measurable concentration of these compounds in the analyzed sample, suggesting efficient extraction and adequate sensitivity of the analytical method used. The chromatogram presented in Figure 8 shows the characteristic elution profile of acetamiprid. The analysis revealed a dominant chromatographic peak, well resolved and clearly defined, with an average retention time of 2.78 minutes.

Table 2 presents the nominal composition of two active substances, lambda-cyhalothrin and acetamiprid, present in a commercial insecticide formulation named K-Optimal EC. The analytical results indicate that this formulation contains 15 g/L of lambda-cyhalothrin and 20 g/L of acetamiprid. These concentrations show that acetamiprid is the predominant compound, at a concentration approximately 1.33 times higher than that of lambda-cyhalothrin. The designation "technical product" associated with the term "EC"

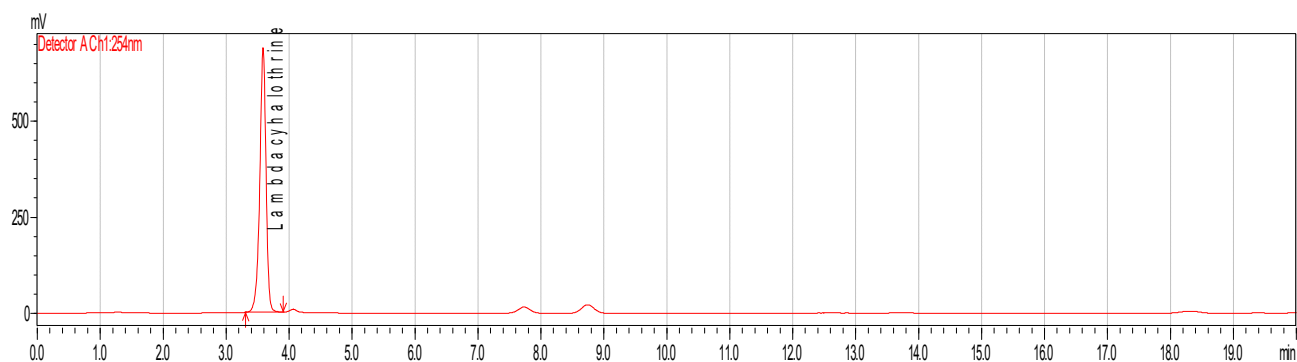


Figure 7. Representative chromatogram showing the retention time of lambda-cyhalothrin

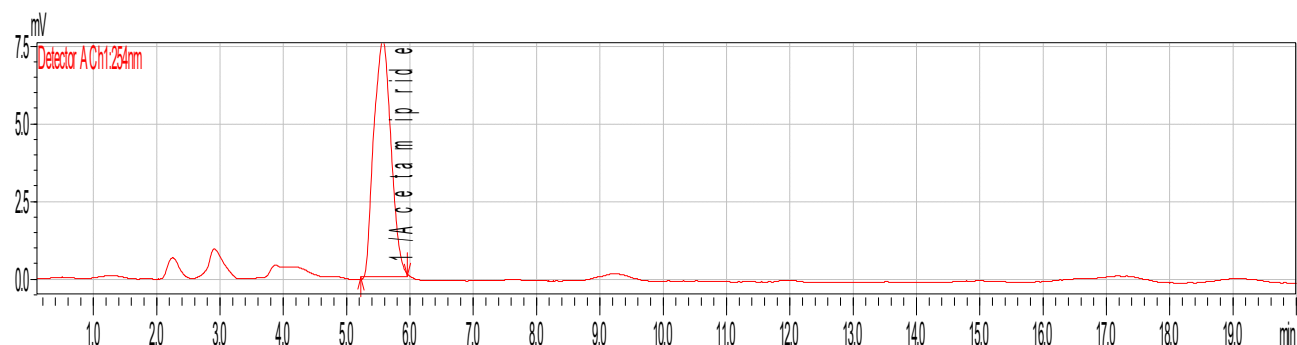


Figure 8. Representative chromatographic profile of acetamiprid retention time

Table 1: Presentation of Sampling Stations and Sample Identifiers

Station	Geographic Location	<i>Allium schoenoprasum</i> Sampling Code	<i>Lactuca sativa</i> Sampling code
Station 1	Port Bouët, Bassam road	ASS1	LS S1
Station 2	Port Bouët airport, exhibition park, right side	ASS2	LS S2
Station 3	Port Bouët airport, exhibition park, left side	ASS3	LS S3

ASS : *Allium schoenoprasum* station ; LSS : *Lactuca sativa* station

Table 2. Concentration, limit of detection, and limit of quantification of the active substances

Active Ingredients	Concentration (g/L)	Detection Limits (µg /L)	Quantification(µg /L)
Lambda Cyhalothrin	15	0,011	0,033
Acetamiprid	20	0,017	0,051

Table 3: Concentrations of lambda-cyhalothrin and acetamiprid residues in *Lactuca sativa* samples

Station	Lambda-Cyhalothrine (µg/L)	Acétamipride (µg/L)
LSS1	< 0,011	< 0,017
LSS2	< 0,011	< 0,017
LSS3	< 0,011	0,020
LOD	0,011	0,017
MRL (Codex Alimentarius 2009)	300	3000

LOD (Limit of Detection). MRL (Maximum Residue Limit)

Table 4. Concentrations of Lambda-Cyhalothrin and Acetamiprid Residues in *Allium schoenoprasum*

Station	Lambda-Cyhalothrin (µg/kg)	l'Acétamiprid (µg/kg)
ASS1	0,022	0,037
ASS2	0,018	0,031
ASS3	< 0,011	< 0,017
LOD	0,011	0,017
MRL (Codex Alimentarius 2009)	5000	3000

LOD (Limit of Detection). MRL (Maximum Residue Limit)

Table 4. Pairwise Comparisons of Lambda-Cyhalothrin Concentrations Between Sampling Stations (p<0,05)

	LSS1	LSS2	LSS3	ASS1	ASS2
LSS2	0,1				
LSS3	0,04	0,28			
ASS1	0,1	0,1	0,04		
ASS2	0,1	0,1	0,04	0,1	
ASS3	0,1	0,1	0,04	0,1	0,1

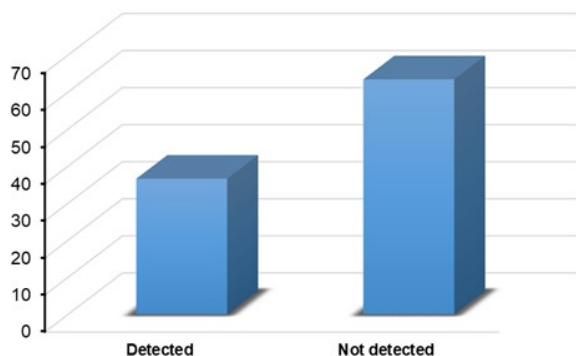


Figure 9. Distribution of samples according to the detection of Lambda-Cyhalothrin and Acetamiprid residues

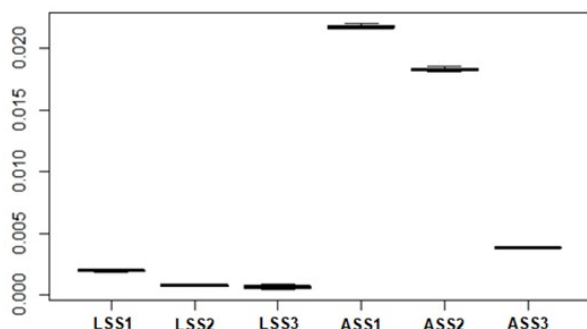


Figure 10. Significant differences in lambda-cyhalothrin concentrations between sampling stations and crop types

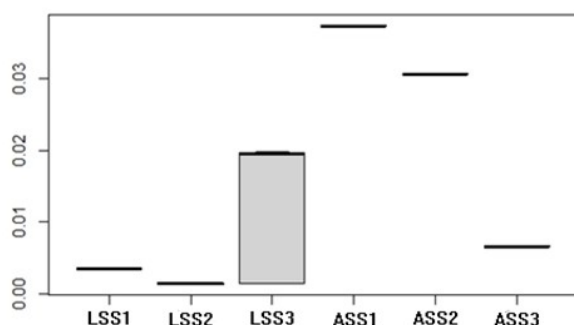


Figure 12. Comparison of acetamiprid concentrations between sampling stations and crop types according to the Mann-Whitney test

(Emulsifiable Concentrate) indicates that this is a concentrated formulation intended to be diluted prior to agricultural or phytosanitary application.

Percentage of Detected Samples: Figure 12 illustrates the proportion of samples containing lambda-cyhalothrin and acetamiprid residues. The results show that 36.59% of the samples exhibited detectable contamination, whereas 63.41% showed no measurable presence of these compounds, with concentrations below the analytical detection limits.

Concentrations of Lambda-Cyhalothrin and Acetamiprid Residues in *Lactuca sativa*: Table 5 shows the absence of lambda-cyhalothrin in all analyzed *Lactuca sativa* samples, with concentrations below the limit of detection (0.011 µg/L). Regarding acetamiprid, only sample S3 exhibited a detectable concentration (0.019 µg/L), which remained well below the maximum residue limit (MRL) of 3000 µg/kg.

LOD (Limit of Detection). MRL (Maximum Residue Limit)

Concentrations of Lambda-Cyhalothrin and Acetamiprid Residues in *Allium schoenoprasum*: Table 6 reveals the presence of lambda-cyhalothrin and acetamiprid residues in *Allium schoenoprasum* from sampling stations S1 and S2, with respective concentrations of 0.022 and 0.037 µg/kg at S1, and 0.018 and 0.031 µg/kg at S2. No residues were detected at station S3. The measured concentrations remained well below the Codex maximum residue limits (MRLs) of 5000 and 3000 µg/kg, respectively.

LOD (Limit of Detection). MRL (Maximum Residue Limit)

Comparison of pesticide residue concentrations between stations and crop types

•**Lambda-Cyhalothrin:** The Mann-Whitney test showed that *Allium schoenoprasum* leaves exhibited significantly higher lambda-cyhalothrin concentrations than *Lactuca sativa* from station S3. However, no significant difference was observed between *Lactuca sativa* from station S2 and *Allium schoenoprasum* leaves from the different sampling stations analyzed.

Acetamiprid : The Mann-Whitney test revealed significant differences in acetamiprid concentrations between S3 *Lactuca sativa* and *Allium schoenoprasum* leaves from stations S1 and S2. The levels measured in S3 *Lactuca sativa* were markedly lower than those in *Allium schoenoprasum* leaves. No significant difference was observed between the other stations, indicating relative homogeneity in the contamination levels of the samples analysed.

DISCUSSION

Composition of the K-Optimal EC formulation: The concentrations of Lambda-Cyhalothrin and Acetamiprid were 15 g/L and 20 g/L, respectively, for the K-Optimal EC insecticide sample. This result is consistent with that reported by OUEDRAOGO *et al.* (2024) in Burkina Faso. In that study, the authors used K-Optimal 35 EC, based on Lambda-Cyhalothrin (15 g/L) + Acetamiprid (20 g/L), to treat plants twenty-one (21) days after sowing.

Detection frequency and quantification limits: The study also revealed that, overall, residues of the K-Optimal insecticide were not detected in 58.3% of the combined *Lactuca sativa* and *Allium schoenoprasum* leaf samples. This result suggests that, although the presence of the pesticide may have been suspected, concentrations were too low to be reliably quantified. Indeed, the measured values fell within the range of instrumental noise, making quantitative interpretation uncertain. From a health perspective, this lack of quantification is equivalent to a negligible or near-zero presence of lambda-cyhalothrin and acetamiprid in the samples analysed.

In the remaining 41.7% of samples, lambda-cyhalothrin and acetamiprid were detected at concentrations ranging from 0.0183 µg/kg to 0.0374 µg/kg. These levels are well below the maximum residue limits (MRLs) set by Codex Alimentarius Commission (2019), namely 5000 µg/kg for lambda-cyhalothrin and 3000 µg/kg for acetamiprid.

Table 5. Pairwise Comparisons of Acetamiprid Concentrations Between Sampling Stations ($p < 0.05$)

	LSS1	LSS2	LSS3	ASS1	ASS2
LSS2	0,1				
LSS3	0,79	0,13			
ASS1	0,1	0,1	0,04		
ASS2	0,1	0,1	0,04	0,1	
ASS3	0,1	0,1	0,79	0,1	0,1

These results indicate that the *Lactuca sativa* and *Allium schoenoprasum* leaves analysed pose no notable health risk in relation to these active substances, thereby complying with national and international food safety standards.

Comparison with previous studies: These results contrast with those of the study conducted by Kpan *et al.*, (2019) at the same market gardening site, where 93.33% of samples from various crops, including *Lactuca sativa*, were found to be non-compliant with respect to lambda-cyhalothrin residues. This difference could be explained by the agricultural practices observed at the time. According to the authors, producers did not comply with good phytosanitary practices, particularly pre-harvest intervals (PHIs) for agrochemical products.

Moreover, many of the techniques used were not suited to market garden crops, which accounted for the high rates of non-compliance with MRLs. In contrast, agricultural and phytosanitary practices at the site have improved considerably in recent years, which may explain the more favourable results obtained in the present study. This same observation was made by Yapo *et al.*, (2021) in their study on the "Level of contamination and health risks associated with the consumption of market garden produce in Korhogo, Côte d'Ivoire." In that study, the authors showed that the low residue values obtained were due, in part, to farmer education and the rational use of pesticides, i.e., use in accordance with manufacturer recommendations (Bakircı *et al.*, 2014).

Differences between crop types: Although none of the measured concentrations of Lambda-Cyhalothrin and Acetamiprid in *Lactuca sativa* and *Allium schoenoprasum* leaves exceeded the current regulatory limits, statistical comparison tests (Kruskal-Wallis and Mann-Whitney) revealed significant differences between the two crop types with respect to contamination by these insecticides. Specifically, *Allium schoenoprasum* leaves from stations S1, S2 and S3 exhibited significantly higher levels of Lambda-Cyhalothrin and Acetamiprid residues than those observed in *Lactuca sativa* sampled at station S3 (LSS3).

This difference can be explained by several factors. On the one hand, phytosanitary practices tend to be more intensive on *Allium schoenoprasum*, a crop particularly vulnerable to insect infestation (FAO, 2015). On the other hand, the physicochemical properties of the active substances contribute to their differentiated behaviour depending on the crop: Lambda-Cyhalothrin, which is lipophilic and non-systemic, and Acetamiprid, which is systemic, tend to persist more readily on the waxy, tubular leaves of *Allium schoenoprasum* (EFSA *et al.*, 2022; Tomlin, 2009). Finally, the very morphology of *Allium schoenoprasum* favours residue retention, in contrast to *Lactuca sativa*, whose broad leaves are more exposed to natural runoff (Nougadère, 2012). These findings highlight an increased risk of contamination of *Allium schoenoprasum* leaves, warranting enhanced and more rigorous monitoring for this type of crop.

REFERENCES

- Agueh V., Degbey C. C., Sossa-Jérôme C., Adomahou D., Paraiso M. N., Vissoh S., Makoutodé M., and Fayomi B., 2015. Niveau de contamination des produits maraîchers par les substances toxiques sur le site de Houéyiho au Bénin. *International Journal of Biological and Chemical Sciences*, 9(1), 542–551. . <https://doi.org/10.4314/ijbcs.v9i1.46>
- Antoine P. and Coulibaly, S., 1989. *L'insertion urbaine des migrants en Afrique*. Paris: ORSTOM, 242 p. https://horizon.documentation.ird.fr/exl-doc/pleins_textes/pleins_textes_7/divers2/26845.pdf.
- Bakircı G. T., Yaman Acay D. B., Bakircı F. and Ötleş S., 2014. Pesticide residues in fruits and vegetables from the Aegean region, Turkey. *Food Chemistry*, 160, 379-392. DOI : 10.1016/j.foodchem.2014.02.051.
- Bricas N., Pape A.S. and Seck P. A., 2004. L'alimentation des villes du Sud : les raisons de craindre et d'espérer. *Cahiers Agricultures*, 13(1), 10-14.
- Codex Alimentarius Commission. 2019. Maximum Residue Limits (MRLs) for Pesticides in Food. FAO/WHO. "Programa Conjunto Fao/Oms Sobre Normas Alimentarias Comité Del Codex Sobre Aditivos Alimentarios." *J. Chem. Inf. Model* 53.9: 1689-1699. <http://www.fao.org/fao-who-codexalimentarius>
- Coulibaly W. D. 2020., Evaluation des pratiques phytosanitaires des maraîchers opérant dans le périmètre de l'aéroport international Félix Houphouët Boigny (Abidjan) et risques pour la santé et l'environnement, INFAS Mémoire d'Ingénieurs des Techniques Sanitaires Option : Hygiène et Assainissement, 92p : 46-47.
- Dieye P. N., 2006. *Arrangements contractuels et performances des marchés du lait local au sud du Sénégal : les petites entreprises de transformation face aux incertitudes de l'approvisionnement*. Thèse de doctorat en agroéconomie, École Nationale Supérieure Agronomique de Montpellier (ENSA Montpellier), Montpellier, France, 175 p.. http://www.repol.info/IMG/pdf/These_P_N_DIEYE.pdf
- Dongmo T., Gockowski J., Hernandez S., Awono L. D. K. and Mbang Moudon R., 2005. L'agriculture périurbaine à Yaoundé. *Tropicultura*, 23(3), 130-135. DOI : 10.7202/602155ar
- European Food Safety Authority (EFSA), Devos Y. Aiassa E. Muñoz-Guajardo I. Messéan A., and Mullins E. 2022. Update of environmental risk assessment conclusions... EU teosinte. *EFSA Journal*, 20(4), e07228. DOI : 10.2903/j.efsa.2022.7228.
- FAO. 2015. Principles and guidance on the selection of representative commodities for extrapolation of maximum residue limits for pesticides to commodity groups (CXG 84-2012, amended 2017). Rome: Food and Agriculture Organization of the United Nations. Available at: <https://www.fao.org/fao-who-codexalimentarius>
- Hmida-Sayari A., Gargouri-Bouzzid R., Bidani A., Jaoua L., Savouré A., and Jaoua S., 2005. Overexpression of Δ 1-pyrroline-5-carboxylate synthetase increases proline

- production... *Plant Science*, 169(4), 746-752. DOI: 10.1016/j.plantsci.2005.05.025
- Institut National de la Statistique (INS), 2022. *Recensement Général de la Population et de l'Habitat (RGPH) 2021 de la Côte d'Ivoire : Résultats globaux*. Ministère du Plan et du Développement, Abidjan, 37 p. <https://plan.gouv.ci/uploads/publications/RGPH2021-RESULTATS-GLOBAUX-VF.pdf>
- Kouamé K. A., Kouassi K. A., Kouassi K. E., Kouassi A. M., and Biémi J. Induced effect of pesticide use in market gardening on environment and human health in Daloa, Ivory Coast. *Revue Ivoirienne des Sciences et Technologie*, 45, 88–105. 2025. https://revist.net/REVIST_45/7-ST-858.pdf
- Kpan K. G. K., Yao B. L., Diémélèou A. C., N'Guettia R. K., Traoré K. S., and Dembélé A., 2019. Pratiques phytosanitaires en agriculture périurbaine et contamination des denrées par les pesticides : cas des maraîchers de Port-Bouët (Abidjan). *Journal of Animal & Plant Sciences*, 41(1), 6847-6863. DOI : 10.35759/JAnmPlSci.v41-1.11
- Midmore D. J., and Jansen H. G. P., 2003. Supplying vegetables to Asian cities.. *Food Policy*, 28(1), 13-27.. DOI : 10.1016/S0306-9192(02)00067-2.
- Nougadère A., Sirot V., Kadar A., Fastier A., Truchot E., Vergnet P. 2012. Total diet study on pesticide residues in France. *Environment International*, 45, 135-150. DOI : 10.1016/j.envint.2012.02.001.
- Ouédraogo C. P., Traoré F., Zongo N. E., Oura A., Boly A., Drabo E., Waongo A., and Dabiré-Binso C., 2024. Évaluation des dégâts et du rôle pollinisateur de trois souches de thrips sur le niébé en culture au Burkina Faso. *Sciences Naturelles et Appliquées*, 43(2), 136–152. <https://revuesciences-techniquesburkina.org>
- Pham D. T., Ghanbarzadeh A., Koç E., Otri S., Rahim S. and Zaidi M., 2006. The bees algorithm — a novel tool for complex optimisation problems. In *Intelligent Production Machines and Systems* (pp. 454-459). Elsevier. DOI : 10.1016/B978-008045157-2/50081-X
- Tano B. F., Abo K., Dembélé A., and Fondio L., 2011. Systèmes de production et pratiques à risque en agriculture urbaine : cas du maraîchage à Yamoussoukro. *International Journal of Biological and Chemical Sciences*, 5(6), 2317-2329. DOI : 10.4314/ijbcs.v5i6.12.
- Tomlin, C. D. S. The Pesticide Manual: A World Compendium (15th ed.). British Crop Protection Council (BCPC), Alton, Hampshire, UK. ISBN: 2009. 9781901396188. Available at: <https://books.google.com/books?id=DZImAQAAMAAJ>.
- Yapo R. I., Ohou-Yao M. J., Ligban R., Kouame P., Mambo V., and Bonfoh B., 2022. Niveau de contamination et risques sanitaires liés à la consommation des produits maraîchers à Korhogo, Côte d'Ivoire. *IJBACS*, 15(5), 2185-2198. DOI : 10.4314/ijbcs.v15i5.37.
