American Journal of Life Sciences
2025, Vol. 13, No. 1, pp. 1-6
https://doi.org/10.11648/j.ajls.20251301.11

Research Article

Effect of a Biopesticide Based on Lemongrass (*Cymbopogon citratus*) Essential Oil on *Cylas puncticollis*, Main Pest of Sweet Potato: Preliminary Laboratory Test

Kinampinan Adelphe Hala[1, *], Koffi Christophe Kobenan[2], Brice Sidoine Essis[1], Konan Evrard Brice Dibi[1], Kouakou Hervé Koua[3]

[1]Root and Tuber Crops Program, National Agricultural Research Centre, Bouaké, Côte d'Ivoire

[2]Cotton Program, National Agricultural Research Centre, Bouaké, Côte d'Ivoire

[3]UFR Biosciences, Natural Environments and Biodiversity Conservation Laboratory, Félix Houphouët-Boigny University, Abidjan, Côte d'Ivoire

Abstract

Particularly rich in nutritional elements, and with excellent agronomic characteristics, sweet potato (*Ipomoea batatas*) is an important crop for food security. It has the potential to improve the nutritional status of rural populations in an inexpensive and sustainable way. In Côte d'Ivoire, sweet potato is grown in all regions, but is unfortunately faced with a number of phytosanitary problems, in particular *Cylas puncticollis*, weevil which is the main threat. This insect can cause crop losses of up to 97%. The aim of this study was to evaluate the efficacy of a biopesticide based on lemongrass (*Cymbopogon citratus*) essential oil against *C. puncticollis*. Five doses (1%, 2%, 4%, 8% and 16%) of biopesticide were prepared from essential oil extracted from lemongrass. These different doses were applied to sweet potato leaves fed to adult *C. puncticollis* individuals reared in the laboratory, compared with an untreated control. Monitoring of the weevil mortality rate for each treatment over 15 days showed that the 8% and 16% doses were the most effective, with mortality rates of 87% and 97% respectively one week after application. These preliminary results constitute an important step in the evaluation of the possibility of using the essential oil of *C. citratus* in an integrated management strategy for sweet potato weevils.

Keywords

Sweet Potato Weevils, Integrated Management, Pests, Crops Protection, Roots and Tubers, Food Safety, Côte d'Ivoire

1. Introduction

Sweet potato (*Ipomoea batatas*), a Convolvulaceae, is one of the root and tuber crops consumed by more than two billion people worldwide [1]. It has interesting agronomic qualities, such as good productivity, a production cycle that is shorter or shorter, and wide climatic and edaphic adaptation for most varieties [2]. It has the potential to combat poverty, reduce blindness and improve the nutritional status of rural populations in an inexpensive and sustainable way [3]. In Côte d'Ivoire, sweet

*Corresponding author: ak.hala2@gmail.com (Kinampinan Adelphe Hala)

Received: 17 December 2024; **Accepted:** 30 December 2024; **Published:** 24 January 2025

Copyright: © The Author(s), 2025. Published by Science Publishing Group. This is an **Open Access** article, distributed under the terms of the Creative Commons Attribution 4.0 License (http://creativecommons.org/licenses/by/4.0/), which permits unrestricted use, distribution and reproduction in any medium, provided the original work is properly cited.

potatoes are grown in all regions. It constitutes a significant proportion of the food consumed and also a source of income [4].

Despite its nutritional and economic advantages, sweet potato production is relatively low in the country. This low production is due to several factors including high pest pressure. Indeed, sweet potato is subject to several pests, the main ones being weevils [5]. These insects can lead to crop losses of over 90% [5-7]. For sustainable agriculture with a view to food security, integrated pest management is recommended. To achieve this, environmentally friendly control methods such as biological control are needed. It is within this framework that the present study was initiated. Its aim is to assess the effect of a biopesticide based on citronella essential oil (*Cymbopogon citratus*) on *Cylas puncticollis* (*Coleoptera, Brentidae*), weevil pest of sweet potato.

2. Material and Methods

2.1. Study Site

This study was conducted at the Food Crop Research Station of the National Centre for Agronomic Research (CNRA) in Bouaké. This Station is located between 7°69' North latitude and 5°03' West longitude, at an altitude of 376 m [8]. The climate in the study area is tropical humid, withfour seasons: a long dry season (November to February), along rainy season (March to June), a short dry season (July toAugust), and a short rainy season (September to October). These periods have become less distinct in recent years [9]. The soils are ferrallitic and gravelly, moderately saturated, shallow, with a sandy-clay texture [10]. The average annualrainfall is 1200 mm, with an average temperature of 25.73°C and annual sunshine duration of 2200 hours [11].

2.2. Plant Material

The plant material consists of lemongrass (Figure 1) and the sweet potato variety J21, known as "Saramani" (Figure 2). This is an orange-fleshed variety, rich in Provitamin A, with a potential yield of 20 t/ha. Its production cycle is 3 to 4 months. J21 variety is popular with users but is susceptible to weevils. The sweet potato leaves used were taken from a plot at the CNRA's Food Crop Research Station in Bouaké.

2.3. Animal Material

The animal material consists mainly of *Cylas puncticollis* adults (Figure 3). Insects were collected from infested sweet potato plots.

2.4. Technical Equipment

The technical equipment consisted of a homogeniser, an oven, petri dishes, tweezers, pairs of scissors and a set of glassware and laboratory consumables (Erlenmeyer flask, test tube, beaker, graduated cylinder, pipette, micropipette, acetone, distilled water, etc.). The Clevenger was used to extract essential oils. This apparatus consists of a heating plate, a pressure cooker, a water cooler, a bulb fed by a marine tank (closed circuit), a lifting support and a Vigreux column.

2.5. Extraction of the Essential Oil of *Cymbopogon citratus* and Preparation of Doses of Biopesticide

The essential oil of *Cymbopogon citratus* was extracted using the method described by Kobénan and *al.* [12]. This method consists of:

1) harvesting *C. citratus* leaves early in the morning;
2) drying the leaves for a week in the shade;
3) extracting the essential oils by steam distillation using a Clevenger for an hour and a half (Figure 4).
4) Store the oil obtained in coloured bottles away from light.

From the essential oil extracted in this way, a biopesticide was formulated at concentrations of 1%, 2%, 4%, 8% and 16%.

Figure 1. *Cymbopogon citratus (Lemongrass).*

Figure 2. *Sweet potato, variety J21 ("Saramani").*

Table 1. *Experimental set-up.*

Object	Number of *C. puncticollis*	Product	Dose	Number of petri dishes (Replicates)
T0: Control	5	None	None	5
D1: Cymbopogon 1%	5		0,4 mL/10 mL	5
D2: Cymbopogon 2%	5		0,8 mL/10 mL	5
D3: Cymbopogon 4%	5	Essential oil of *C. citratus*	1,6 mL/10 mL	5
D4: Cymbopogon 8%	5		2 mL/10 mL	5
D5: Cymbopogon 16%	5		4,8 mL/10 mL	5

Figure 3. *Cylas puncticollis adult.*

Figure 4. *Extraction of the essential oil of Cymbopogon citratus.*

2.6. Monitoring and Data Collection

The mortality rate of C. puncticollis was monitored for each treatment. To do this, checks were carried out every morning for a fortnight from the start of the trial. They consisted of counting the dead individuals, which were systematically removed from the rearing boxes.

The cumulative mortality rate of C. puncticollis was then calculated as follows:

$$M\ (\%) = \frac{\sum Cp\ \ morts}{\sum Cp\ \ introduits\ \ par\ \ boîte\ \ de\ \ pétri}\ \times\ 100$$

(M = Taux de mortalité cumulée de *C. puncticollis*)

2.7. Statistical Analysis

Shapiro-Wilk test was first applied to check the normality of the variables measured. As the data were all independent means, when the Shapiro-Wilk test showed that they followed a normal distribution, a one-way analysis of variance (ANOVA 1) was performed. Means were compared using the Student-Newman-Keuls test at the 5% significance level (α = 0.05). All statistical analyses were performed using JMP Pro 17.1.0 software.

3. Results

3.1. Effect of Different Doses of *Cymbopogon citratus* on the Mortality of *Cylas Puncticollis*

The five doses of the biopesticide based on *Cymbopogon citratus* essential oil were toxic to Cylas puncticollis. This progressive toxicity became apparent after the 5th day after, when a cumulative mortality rate of 50% was recorded with the treatments Cymbopogon 16%, 8% and 4%. The lethal time for 50% of the population (TL50) was 6 days with treatment D2 (Cymbopogon 2%) and 7 days for treatment D1 (Cymbopogon 4%) (Figure 5).

The lethal time for 70% of the population (TL70) was 6 to 7 days for the Cymbopogon 16%, 8%, 4% and 2% treatments, while it was 9 days for treatment D1 (Cymbopogon 4%.) and 10 days for the untreated control.

The 16%, 8% and 4% doses of Cymbopogon resulted in a 90% mortality rate after 8 days. This level of mortality was only reached after 12 days for D2 (2% Cymbopogon) and 14 days for D1 (1% Cymbopogon) and the untreated control.

Only the Cymbopogon 16% treatment achieved 100% cumulative mortality at the end of the 8th day after application. For all the other treatments, this mortality rate was only achieved between the 14th and 15th day after application (Figure 5).

3.2. Efficacy of Different Doses of *C. Citratus* Against *C. Puncticollis* one Week After Application

Statistical analysis revealed a significant difference between treatments. Four homogeneous groups A, B, C, D and E were determined (Figure 6).

With a mortality rate of 97%, treatment D5 (Cymbopogon 16%) was the most effective. This was followed by treatment D4 (Cymbopogon 8%) which gave a mortality rate of 87%. Doses of 2% and 4% (treatments D2 and D3) of the biopesticide based on the essential oil of *C. citratus* gave a mortality rate of 83%. Treatment D1 (Cymbopogon 1%) gave the lowest mortality rate (67%).

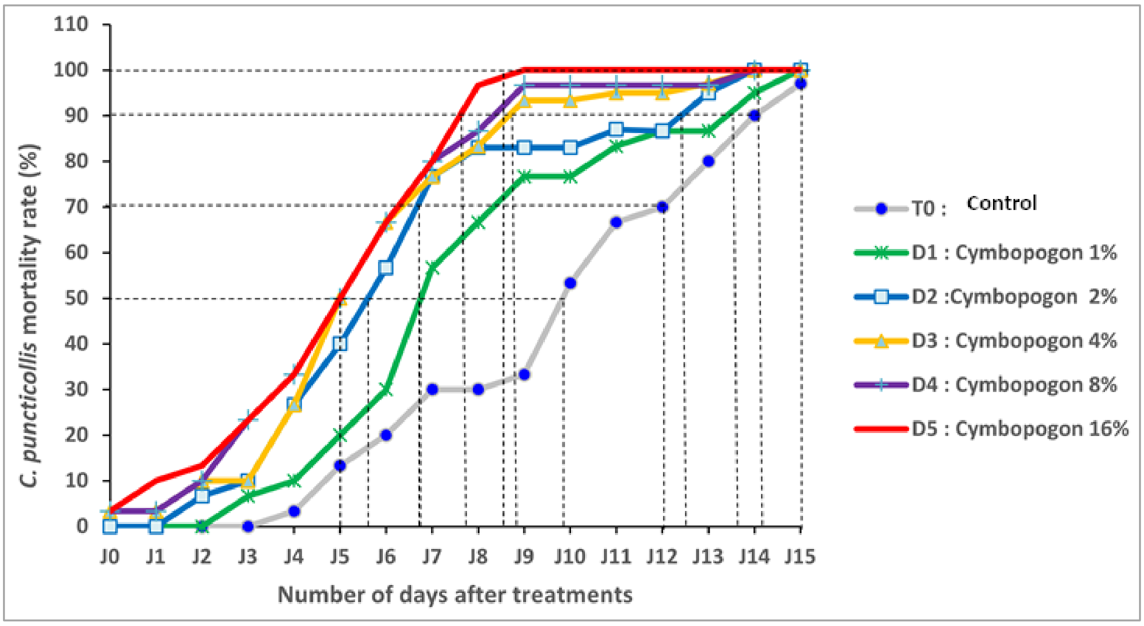
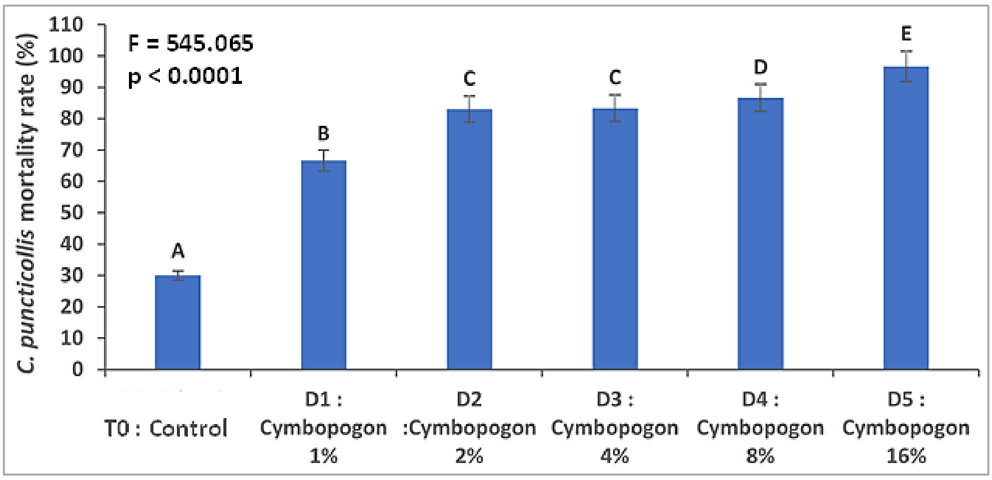


Figure 5. *Cumulative mortality rate of Cylas puncticollis according to the treatments.*



Treatments marked with the same letter belong to the same homogeneous group

Figure 6. *Comparison of treatments one week after application.*

4. Discussion

This study highlighted the effectiveness of a biopesticide based on lemongrass (*Cymbopogon citratus*) essential oil against the sweet potato weevil *Cylas puncticollis* under laboratory conditions. The essential oil of this plant has insecticidal properties against various pests [13, 12]. Togola and collaborators in 2013 [14] also demonstrated the efficacy of *Cymbopogon citratus* and *Eucalyptus camaldulensis* essential oils in protecting stored rice against the *Sitophilus oryzae* beetle (Coleoptera: Curculionidae) and the *Sitotroga cerealella* butterfly (Lepidoptera: Gelechiidae).

In the present study, the biopesticide was applied to sweet potato leaves that had been used as food by the weevils, and not directly to them. The essential oil of *C. citratus* would therefore have an effect by ingestion on *C. puncticollis*. Such an effect of this essential oil had been observed by Plata-Rueda and colleagues in their work on the pest *Anticarsia gemmatalis* in 2021 [15].

The mortality rate of *C. puncticollis* increased progressively with increasing doses of the biopesticide. This could be explained by the increased toxicity of this biopesticide as the dose increased. Increasing doses generally cause an increase in the intensity and diversity of toxic effects, which is known as the dose-response or exposure-response relationship [16].

In the future, the 8% and 16% doses of this biopesticide will have to be evaluated against *C. puncticollis* under conditions of natural infestation in the field to confirm these results.

5. Conclusion

This study evaluated the effect of a biopesticide based on lemongrass (*Cymbopogon citratus*) essential oil on *Cylas puncticollis*. The results showed that this biopesticide was toxic to the sweet potato weevil *C. puncticollis*. Of the five doses tested (1%, 2%, 4%, 8% and 16%), 16% and 8% were the most effective. These preliminary results are an important step in assessing the potential use of *C. citratus* essential oil in an integrated management strategy for sweet potato weevils.

Abbreviations

ANOVA	One-way Analysis of Variance
CNRA	National Centre for Agronomic Research
FCRS	Food Crop Research Station
UFHB	Félix Houphouët-Boigny University

Acknowledgments

The authors would like to express their gratitude to the National Centre for Agronomic Research, in particular the Food Crop Research Station by the Roots and Tubers Program for support in this study. They would also like to thank AFD and INTERCOTON for co-financing this work through the RESCO project.

Author Contributions

Kinampinan Adelphe Hala: Conceptualization, Data curation, Formal Analysis, Methodology, Software, Writing – original draft, review & editing

Koffi Christophe Kobenan: Conceptualization, Data curation, Formal Analysis, Methodology, Software, Writing – review & editing

Brice Sidoine Essis: Conceptualization, Methodology, Resources, Validation, Visualization, Writing – review & editing

Konan Evrard Brice Dibi: Funding acquisition, Project administration, Resources, Supervision, Validation, Visualization

Kouakou Hervé Koua: Supervision, Validation, Visualization, Writing – review & editing

Data Availability Statement

The data is available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] Lebot V, Champagne A, Malapa R. & Shiley D. NIR Determination of Major Constituents in Tropical Root and Tuber Crop Flours. *Journal of Agricultural and Food Chemistry*. 2009, 57(22): 10539–10547. https://doi.org/10.1021/jf902675n

[2] Doussoh A. M., Dangou J. S., Houedjissin S. S., Assogba A. K. & Ahanhanzo C. Analyse des connaissances endogènes et des déterminants de la production de la patate douce [Ipomoea batatas (L.)], une culture à haute valeur socioculturelle et économique au Bénin. *Int. J. Biol. Chem. Sci.* 2016, 10(6): 2596-2616. https://doi.org/10.4314/IJBCS.V10I6.16

[3] Brobbrey A. Growth, yield and quality factors of sweetpotato *(Ipomoea batatas* (L.) Lam) as affected by seedbed type and fertilizer application. Thesis submitted to the Department of Crop and Soil Sciences, Faculty of Agriculture, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana, in partial fulfilment of the requirements for the award of the degree, Master of Philosophy in Agronomy (Crop Physiology). June 2015, 95p. https://ir.knust.edu.gh/server/api/core/bitstreams/ff341b30-33ea-47cf-9a57-308dd8566b27/content

[4] Dibi K. E. B., Essis B., N'Zué B., Kouakou A. M., Zohouri G. P., Assouan A. B. & Mourik T. M. Participatory selection of orange-fleshed sweetpotato varieties in north and north-east Côted'Ivoire. *Open Agriculture*. 2017, 2(1), 83-90. https://doi.org/10.1515/opag-2017-0009

[5] Baimey H., Fanou A., Adandonon A., Behoundja-Kotoko O., Houssou N. A. G. & Agbede R. D. Sweet potato *Ipomoea batatas* (L.) storage practices used in southern Benin and the use of entomopathogenic nematodes to control sweet potato weevil (*Cylas puncticollis* Boheman) under laboratory conditions. *Journal of Entomology and Zoology Studies*. 2017, 5(6): 549-556. https://www.entomoljournal.com/archives/2017/vol5issue6/PartH/5-4-307-961.pdf

[6] Denon D. et Mauleon H. Le charançon de la patate douce en Guadeloupe: *Cylas formicarius* menace gravement la survie de la culture. *PHYTOMA – La défense des végétaux*. 2004, Num 573, pp 14-15. https://pascal-francis.inist.fr/vibad/index.php?action=getRecordDetail&lang=fr&idt=15936328

[7] Dibi K. E. B., Essis B. S. & N'zué B. Techniques culturales de la patate douce. Manuel de formation des agents de développement et des producteurs. Appui à la promotion de la Patate Douce à Chair Orange en Côte d'Ivoire / Projet Change (CNRA / HKI). 2015, 53p.

[8] Nzi J., Kouamé C., N'guetta A., Fondio L., Djidji A. et Sangare A. Evolution des populations de *Bemisia tabaci* Genn. Selon les variétés de tomate (*Solanum lycopersicum* L.) au Centre de la Côte d'Ivoire. *Sciences & nature*. 2010, 7(1). https://doi.org/10.4314/scinat.v7i1.59918

[9] Brou, Y. T., Akindès, F. et Bigot, S. La variabilité climatique en Côte d'Ivoire: entre perceptions sociales et réponses agricoles. *Cahiers Agricultures*. 2005, 14(6) 533–540. https://doi.org/10.13140/2.1.5174.3368

[10] Ettien D. J. B. Intensification de la production d'igname (*Dioscorea* spp.) par la fertilisation minérale et l'identification de nouvelles variétés en zones forestière et savanicole de Côte d'Ivoire. Thèse de Doctorat unique en science de la terre, option Agro-pédologie, Université de Cocody, Abidjan. 2004, 187 p.

[11] Traore K., Sorho F., Dramane D. D. et Sylla M. Adventices hôtes alternatifs de virus en culture de Solanaceae en Côte D'Ivoire. *Agronomie Africaine*. 2013, 25(3), 231‑237. https://www.ajol.info/index.php/aga/article/view/100651

[12] Kobenan K. C., Kouakou M., N'goran K. E., Bini K. K. N., Kouakou B. J., Amangoua N. F. & Tehia K. E. Bien protéger le cotonnier contre les bioagresseurs avec les huiles essentielles des plantes aromatiques issues de la flore ivoirienne. Fiche technique CNRA. 2024, 2 p. https://cnra.ci/bien-proteger-le-cotonnier-contre-les-bioagresseurs-avec-les-huiles-essentielles-des-plantes-aromatiques-issues-de-la-flore-ivoirienne/

[13] Karima T. T. Extraction et caractérisation des huiles essentielles de dix plantes aromatiques provenant de la région de Kabylie (Nord Algérien). Evaluation de leurs effets sur le bruche du niébé *Callosobruchus maculatus* (Coleoptera: Bruchidae). Thèse de Doctorat en Sciences Biologiques, Université Mouloud Mammeri de Tizi-Ouzou, Faculté des Sciences Biologiques et Sciences Agronomiques, Département de biologie Animale et végétale, Algérie. 2015, 206 p.

[14] Togola A., Silvie P., Seck P. A., Menozzi P., Nwilene F. E., Glitho I. A., Chougourou D. Effectiveness of essential oils of *Eucalyptus camaldulensis* and *Cymbopogon citratus* in protecting stored rice against *Sitophilus oryzae* and *Sitotroga cerealella*. In: 9th Conference on Integrated Protection of Stored Products (PIPS 2013), Bordeaux, France, 1- 4 July, 2013. s. l.: s. n., Diaporama, 1 p. https://agritrop.cirad.fr/570167/1/document_570167.pdf

[15] Plata-Rueda A., Fiaz M., Brügger B. P., Cañas V., Coelho R. P., Zanuncio J. C., Serrão J. E. Lemongrass essential oil and its components cause effects on survival, locomotion, ingestion, and histological changes of the midgut in *Anticarsia gemmatalis* caterpillars. *Toxin Reviews*. 2021, *41*(1), 208–217. https://doi.org/10.1080/15569543.2020.1861468

[16] Commission des Normes, de l'Equité, de la Santé et de la Sécurité du Travail (CNESST). Notions de toxicologie. *Bibliothèque et Archives nationales du Québec*. 2024, ISBN 978-2-550-97518-2 (PDF). 56 p. Available from: https://www.cnesst.gouv.qc.ca/sites/default/files/documents/notions-de-toxicologie.pdf (accessed 6 December 2024).