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(Research Article)

Efficacy of two biopesticides in the management of the Mango Stone Weevil (Coleoptera: Curculionidae), a major pest of Mangoes in Côte d'Ivoire

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Abstract

In Côte d'Ivoire, mango is the third most exported fruit to Europe. However, mango production faces threats from certain insect pests such as fruit flies and, more recently, the mango stone weevil, which causes up to 90% loss of marketable fruits for export in infested countries. The objective of this study was to evaluate the effectiveness of biopesticides in controlling the mango stone weevil. The experimental design used was a Fisher block, with 3 treatments and 3 replications. The products tested (Neem oil; Limocide 60EC), as well as the reference product (Sauveur), were applied at three different concentrations on 100 adult weevils each. This study was conducted at the laboratory of the CNRA Lataha Research Station (Korhogo, Côte d'Ivoire). The results showed that Limocide 60 EC, applied at concentrations of $4{,}18.10^{-3}$ g/ml and $3{,}39.10^{-3}$ g/ml, caused mortality rates above 50% in adult weevils within 24 hours, similar to the reference product Sauveur, for which all tested concentrations were effective. These results highlight the potential of biopesticides for the control of mango stone weevils. Further field tests are recommended before their widespread use.

Keywords: Weevil; Biopesticides; Mango; Pest Control; Côte d'Ivoire

1. Introduction

The mango tree (*Mangifera indica* L.) belongs to the *Anacardiaceae* family, which includes species such as cashew and pistachio [1]. Native to South Asia and widely cultivated in tropical countries for its fruit, the mango tree has significant nutritional importance for humans. Economically, mango production provides jobs and contributes to the development of producing countries [2]. Because of its nutritional properties, mango consumption is recommended due to its richness in amino acids, carbohydrates, organic acids, proteins, and vitamins [3]. Mainly grown in northern Côte d'Ivoire, mango is the third most important cash crop after cotton (Gossypium hirsutum L.) and cashew (Anacardium occidentale L.), and the second most exported fruit after bananas [4]. Since 2017, with more than 33,000 tons of mangoes exported, Côte d'Ivoire has become the leading West African mango-exporting country, followed by Mali and Senegal, and the third largest global supplier to the European market after Brazil (100,000 t) and Peru (80,000 t) [5]. However, mango production, although significant in recent years, still faces various constraints, the most serious of which are caused by insect pests. Among these pests is the mango stone weevil, which causes fruit losses of over 90% of marketable fruits for export [6,7]. In Guadeloupe, mango exports were banned due to the presence of this insect in mango orchards [8]. In Côte d'Ivoire, Minhibo et al. [9] reported the presence of the mango stone weevil in mango orchards, with production losses of 40%. This study aims to provide an alternative to synthetic chemical insecticides by using biological products with insecticidal properties for managing the mango stone weevil in orchards in Côte d'Ivoire.

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2. Materials and methods

2.1. Study Site

This study was conducted at the CNRA research station located in the sub-prefecture of Lataha, in the department of Korhogo. The station is located 22 km from Korhogo in northern Côte d'Ivoire. It covers an area of 40 hectares, situated at 9°34′ N latitude and 5°34′ W longitude, at an altitude of 350 m (Figure 1).The climate is Sudanian, with two distinct seasons: a dry season from November to April and a rainy season from May to October. Annual rainfall averages 1400 mm in wet years and 1000 mm in dry years. The natural vegetation consists of wooded savannah. The soil is ferralitic, moderately to heavily degraded [10].

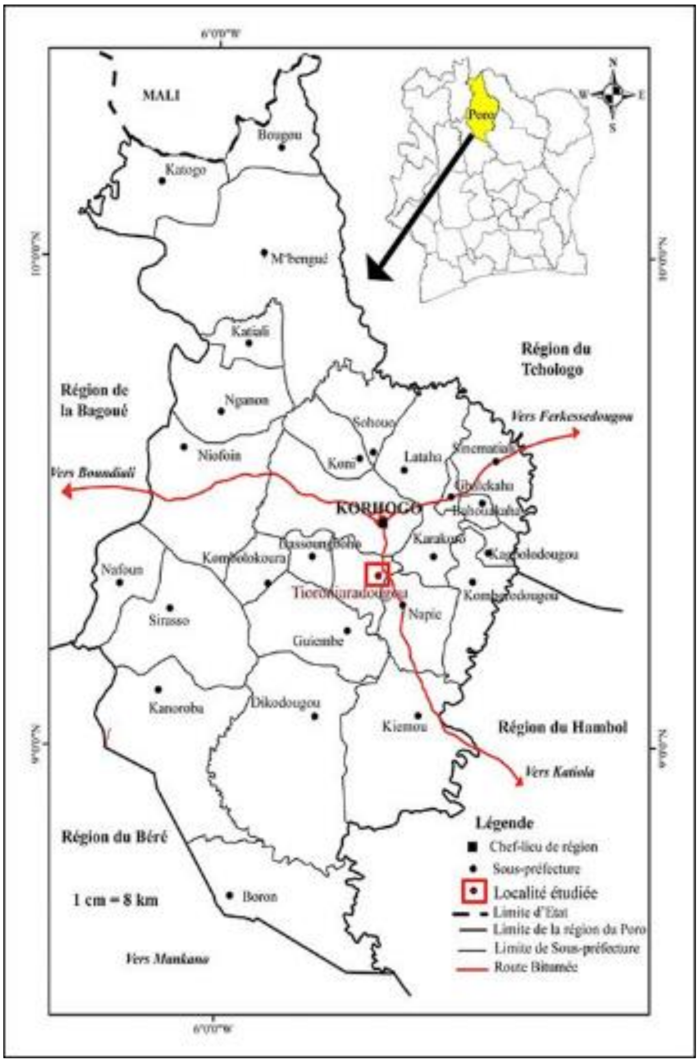

Figure 1 Location map of the study area

2.2. Biological material

The biological material consisted of the mango stone weevil at all stages of development. The plant material consisted of mango trees of the Kent (early) and Brooks (late) varieties, aged between 15 and 20 years.

2.3. Products Used for Testing

Three products were tested: Limocide 60 EC: A biopesticide based on sweet orange essential oil (*Citrus sinensis*), with D-limonene as the active ingredient. Neem oil (*Azadirachta indica* L., 1753): A biological insecticide containing Azadirachtin as the active ingredient. Sauveur 62 EC: A synthetic binary insecticide combining Acetamiprid (32 g/L) and Lambda-cyhalothrin (30 g/L). It was used as the reference insecticide in this study.

2.4. Concentration of the Tested Products

The dilution of the different doses produced the following concentrations

Table 1 Concentrations of the different products tested

Product	Recommended Dose (ml)	Dilution (ml)	Concentration g/ml
Limocide 60 EC	6 ml	80 ml	$4{,}18.10^{-3}$
		100 ml	$3{,}39.10^{-3}$
		400 ml	$8{,}86.10^{-4}$
Neem (Krishi)	2 ml	80 ml	$3{,}65.10^{-6}$
		100 ml	$2{,}94.10^{-6}$
		400 ml	$7{,}46.10^{-7}$
Sauveur 62 EC (l'Acétamipride 32 g/l + Lambdacyhalothrine 30 g/l	4ml	80 ml	$2{,}95.10^{-3}$
		100 ml	$2{,}38.10^{-3}$
		400 ml	$1{,}18.10^{-3}$

3. Methodology

3.1. Experimental Design

The experiment was conducted in a Fisher block design with three (3) replications and three (3) treatments (Neem oil, Limocide, and Sauveur 62 EC). Each treatment was applied to 100 individuals per replication, i.e., 300 individuals per treatment. The individuals were kept in rearing cages by blocks. Each treatment block included an untreated control. The different concentrations (Table I) were applied, and dead and live individuals were counted at 24, 48, and 72 hours after treatment.

3.2. Parameters evaluated

The mortality rate was calculated after 24, 48, and 72 hours following treatment. To avoid overestimating the effectiveness of the products tested, mortality rates were corrected using Abbott's formula [11] to neutralize the effect of natural mortality

$$Mc = \frac{Mo - Mt}{100 - Mt} * 100$$

- Mc: corrected mortality
- Mt: mortality rate recorded in the control
- Mo: mortality rate recorded in the trials

3.3. Statistical Analysis

A one-way ANOVA at the 5% significance level was performed to compare the mortality rates of the mango stone weevil according to the treatments. When significant differences were observed, Tukey's HSD test was used to compare means. A hierarchical cluster analysis was conducted to group products based on their effectiveness. Analyses were performed using R software version 4.1.3.

4. Results

4.1. Evaluation of Product Efficacy According to Concentrations

The analysis of variance ($p < 0{,}001$) showed a significant difference in mortality rates among the different concentrations and products. The biopesticide Limocide, at concentrations of $3{,}39.10^{-3}$ g/ml and $4{,}18.10^{-3}$ g/ml, was the most effective, producing the highest mortality rates. Mortality rates were ≥50% at 24 hours and over 60% at 72 hours. The lowest mortality rates were recorded at the concentration of $8,86.10^{-4}$ g/ml, ranging between 18,33 ± 6,00% and 28,33 ± 3,33% at 72 hours. All concentrations of Neem oil were ineffective, producing mortality rates below 50%, ranging between 2,66 ± 1,45% and 26 ± 3,51%. The reference product Sauveur induced mortality rates between 60% and 100% for all concentrations tested (Table II).

4.2. Hierarchical Classification of Tested Products

The hierarchical classification based on the mortality rates of adult mango stone weevils revealed two distinct groups. Group I: Treatments that effectively controlled the weevil population, including Limocide 60 EC (sweet orange essential oil) and the reference product Sauveur 62 EC. These treatments induced mortality rates ≥50% at 24 hours. Group II: Treatments that were ineffective, represented by Neem oil (Figure 2).

Table 2 Efficacy of the different product concentrations tested

Product	Concentrations (g/ml)	24 H	48 H	72 H	Mean
Limocide 60 EC	$4,18.\ 10^{-3}$	$81,66±6,00^{c}$	$88,33±1,66^{f}$	$93,33±1,66^{f}$	$87,77±3,38^{c}$
	$3,39.10^{-3}$	$55,00±2,88^{b}$	$61,00±4,58^{a}$	$69,33±5,20^{b}$	$61,77±4,15^{b}$
	$8,86.10^{-4}$	$18,33±6,00^{de}$	$27,66±2,66^{b}$	$28,33±3,33^{d}$	$24,77±3,22^{d}$
Neem	$3,65.10^{-6}$	$22,66±2,66^{d}$	$23,66±3,17^{bc}$	$26±3,51^{d}$	$24,10±0,98^{d}$
	$2,94.10^{-6}$	$13,66±0,88d^{ef}$	$14,33±1,45^{cd}$	$14,66±1,20^{c}$	$14,21±0,29^{de}$
	$7,46.10^{-7}$	$2,66±1,45^{ef}$	$4,66±1,45^{de}$	$6,00±2,00^{e}$	$4,44±0,26^{e}$
Sauveur 62 EC	$2,95.10^{-3}$	$92,33±1,45^{c}$	$98,33±1,66^{f}$	100±0,00f	$96,88±2,32^{c}$
	$2,38.10^{-3}$	$77,66±1,45^{ac}$	$86,66±1,66^{f}$	96,33±0,88f	$86,88±5,39^{ac}$
	$1,18.10^{-3}$	$62,66±3,71^{ab}$	$65,00±2,88^{a}$	83,33±1,66a	$70,33±6,53^{ab}$
Control treatment		$0±0^{f}$	$0±0^{e}$	$0±0^{e}$	$0±0^{e}$
P-value		<0,001	<0,001	<0,001	<0,001
F		112,77	233,52	262,19	96,52

Means followed by the same letters are not significantly different (Tukey's HSD test, $p < 0.05$)

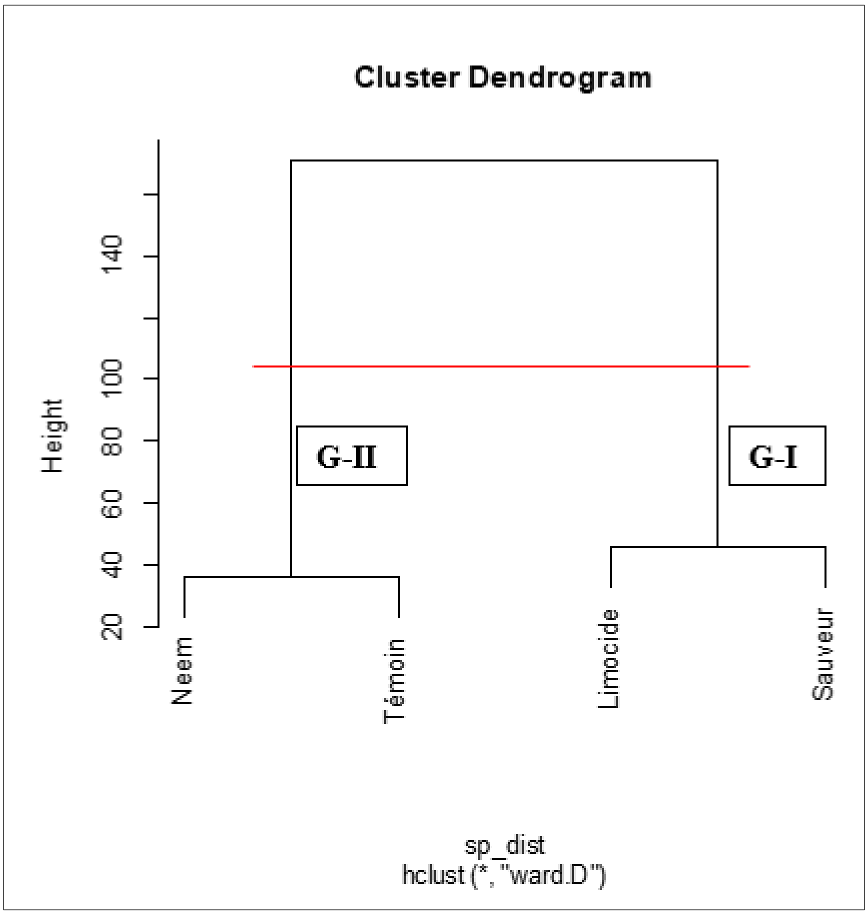

Figure 2 Hierarchical classification of the tested products

5. Discussion

The results demonstrated that the biopesticide Limocide 60 EC significantly reduced the mango stone weevil population under semi-controlled conditions. Compared with the reference product Sauveur 62 EC, Limocide 60 EC achieved mortality rates above 50% at concentrations of 3.39×10^{-3} g/ml and 4.18×10^{-3} g/ml. This effectiveness could be attributed to the presence of active ingredients such as limonene in the product. Essential oils rich in monoterpenes, such as limonene, act by disrupting the insect nervous system, causing paralysis and death. Additionally, limonene functions as a respiratory inhibitor and damages the insect cuticle, increasing susceptibility to dehydration [12]. According to Kim et al. [13], essential oils rich in monoterpenes are effective against various beetles, including species closely related to weevils. Singh et al. [14] reported over 80% mortality in weevils exposed to oils rich in volatile compounds. The biopesticide based on Neem oil showed low mortality rates on adult mango stone weevils under controlled conditions. This could be explained by the fact that Neem oil is not a contact insecticide but rather acts as an anti-feeding agent. These products contain active chemical substances that disrupt insect feeding behavior. According to Isman [15], azadirachtin, the active ingredient in Neem oil, stimulates deterrent-specific cells in chemoreceptors. This active compound also blocks the activation of sugar receptor cells, which normally stimulate feeding, leading to food rejection [16]. The toxic and repellent effects of Neem may depend on its chemical composition and the insect's sensitivity level. This natural active compound does not immediately kill insects but acts as a repellent (anti-feeding), disrupting their growth and reproduction. In fact, azadirachtin appears to block ecdysone secretion, the hormones essential for insect growth. Without ecdysone, insects cannot molt, there by halting their life cycle [17].

6. Conclusion

At the end of this study, compared with the reference product Sauveur, Limocide 60 EC proved to be the most effective, causing mortality rates greater than or equal to 50% within 24 hours at concentrations of 3.39×10^{-3} g/ml and 4.18×10^{-3} g/ml. Neem oil showed mortality rates below 50% after 72 hours. However, given the results obtained under semi-controlled conditions, we recommend that these biopesticides be tested under field conditions to evaluate their effectiveness before widespread use.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare that there are no conflicts of interest.

Disclaimer (Artificial Intelligence)

The authors hereby declare that no generative Artificial Intelligence technologies, such as large language models (ChatGPT, COPILOT, etc.) or text-to-image generators, were used during the writing or revision of this manuscript.

References

[1] Kumar, M., Saurabh, V., Tomar, M., Hasan, M., Changan, S., Sasi, M., Maheshwari, C., Prajapati, U., Sing, S., Prajapat, R.K., Mekhemar, M. 2021. Mango (*Mangifera indica* L.) Leaves: Nutritional Composition, Phytochemical Profiles, and Health Promoting Bioactivities Antioxidants, 10 (2), 299. https://doi.org/10.3390/antiox10020299.

[2] N'Dépo O. R., Hala N. F., Allou K., Aboua L. R., Kouassi K. P., Vayssières J. F., and De Meyer M. (2009). Abundance of fruit flies in the fruit production zone of Côte d'Ivoire: dynamics of *Bactrocera invadens* (Diptera: Tephritidae) populations. *Fruits*, 64(5): 313-324.

[3] Mukherjee S. K. (1997). Introduction, Botany and importance. In: Litz R. E. The Mango Botany, Production and Uses. CAB International, Wallingford, UK, 1-20.

[4] N'Dépo O. R. (2010). Biology and Ecology of *Bactrocera invadens* Drew, Tsuruta and White, 2005 (Diptera: Tephritidae), major pest of fruit orchards in Côte d'Ivoire: potential for rational chemical control of fruit flies. PhD Thesis, University of Cocody, Abidjan, Côte d'Ivoire, 177 p.

[5] Mieu B. (2017). Côte d'Ivoire: The government wants to restructure the mango sector. Jeune Afrique. Accessed June 19, 2020.

[6] Bagle, B.G., and Prasad, V.G. (1985). Studies on varietal incidence and control of mango stone weevil *Sternochetus mangiferae* (Fabricius) (Coleoptera : Curculionidae). *Indian Journal of Entomology*, 47(3): 362-364.

[7] Verghese, A. (2000). Recent studies on the management of mango stone weevil *Sternochetus mangiferae* Fab. (Coleoptera: Curculionidae) in South India. *Acta Horticulturae*, 509: 819-822.

[8] Laure D. R., Fabrice L. B., David H. (2007). *Sternochetus mangiferae* (Fabricius) (Coleoptera: Curculionidae), mango stone weevil, in mango orchards in Guadeloupe. *Fruits*, 62, 279–293. DOI: 10.1051/fruits: 2007024.

[9] MINHIBO Magloire Yves, ABY N'goran (2021). Study on the biology of the mango stone weevil (*Sternochetus mangiferae*) and exploratory trial for the validation of control methods against this pest in Côte d'Ivoire. Annual Report. 26 p.

[10] Djaha A., N'Da A. A., Hala N., Koffi E., and N'Guessan A. (2008). Good practices for cashew cultivation in Côte d'Ivoire. Technical sheet (CNRA), 4 p.

[11] Abbott W.S. (1995). A method of computing the effectiveness of an insecticide. *Journal of Economic Entomology*, 18: 265-267. DOI: https://doi.org/10.1093/jee/18.2.265a.

[12] Regnault-Roger, C., Vincent, C., and Arnason, J.T. (2012). Essential oils in insect control: low-risk products in a high-stakes world. *Annual Review of Entomology*, 57, 405-424.

[13] Kim, S. I., Roh, J.Y., Kim, D. H., Lee, H. S., and Ahn, Y. J. (2011). Insecticidal activities of aromatic plant extracts and essential oils against *Sitophilus oryzae* and *Callosobruchus chinensis*. *Journal of Stored Products Research*, 47(2), 99-105.

[14] Singh, B. K., and Gupta, V. K. (2018). Natural bioactive products in sustainable agriculture: A review. *Journal of Pharmacognosy and Phytochemistry*, 7(4), 18-25.

[15] Isman M.B. (2002). Lepidoptera, butterflies and moths. In: Schmutterer H. (ed) The Neem Tree, 2nd ed. The Neem Foundation, Mumbai, India, pp. 378–401.

[16] Diabaté, S., Togola, A., Kébé, B. I., Boulanger, R., and Glitho, I. A. (2014). The effect of pesticides and aqueous extracts of *Azadirachta indica* (A. Juss) and *Jatropha curcas* L. on *Bemisia tabaci* (Gennadius) and *Helicoverpa armigera* (Hübner) found on tomato plants in Côte d'Ivoire. *Journal of Applied Biosciences*, 80, 7132-7143.

[17] Mouffok B., Raffy E., Urruty N., and Zjcola J. (2008). Neem, an effective biological insecticide. Paul-Sabatier University, Toulouse (France), 16 p.