Plant-derived Semiochemical Strategy for Sustainable Management of Coconut Whitefly (*Aleurodicus cocois*) using Trunk Injection Techniques

H.M.S.M. Herath[1], A.D.N.T.Kumara [2] and A.M.K.G. Muhandiram [3]

[1,2,3]*Department of Biosystems Technology, South Eastern University of Sri Lanka, Sri Lanka*

[1]shameeramadhushan98@gmail.com , [2]adntkumara@seu.ac.lk , [3]kasnuimuhandiram96@seu.ac.lk

Abstract

In Sri Lanka, the coconut industry, which is a major contributor to the national economy, is under severe threat from the recently introduced pest, the coconut whitefly (Aleurodicus cocois). This pest's resistance to conventional pesticides combined with the height of coconut trees has highlighted the need for sustainable management alternatives. The aim of this study is to develop and evaluate a plant semiochemical-based strategy for coconut whitefly control, using stem injection as a systemic alternative to chemical pesticides. The approach offers a sustainable solution by reducing pest populations without negatively impacting the ecosystem. Plant extracts of seeds and leaves of Strychnos nux-vomica (Goda kaduru), neem, mint and clove oil were formulated and tested. Four successful formulations were identified and initially tested by direct spraying. Building on these results, the formulations were combined with systemic recipients such as urea, NaCl, KCl and citric acid and evaluated by strain injection methods. Field trials showed significantly higher mortality rates (68%, 95.85%, 93.27% and 94.66%) for formulations 1 to 4 compared to the untreated control (p < 0.005). Stem-injected palms showed a gradual decline in whitefly populations, although adverse weather conditions prevented continuous monitoring. These findings suggest that repeated applications are necessary for long-term success.

Keywords: Alternative pesticides, Coconut whitefly, Plant semiochemicals, Trunk injection, Sustainable pest management.

I. INTRODUCTION

In Sri Lanka, the coconut palm, also known as *Cocos nucifera*, serves not only as a symbol of the country's thriving agricultural sector but also as a symbol of the country's cultural identity and its ability to recover economically. The sector, which spans around 410,000 hectares, serves as the foundation of rural economies, providing employment opportunities for thousands of small-scale farmers and making a substantial contribution to the economy of the country. Many aspects of everyday life are influenced by its products, including the gastronomic pleasures that are enjoyed all throughout the country, its function in traditional medicine, and the manufacture
of coir, which is a versatile material that is used in a broad variety of applications (Al-Ballaa, 2023). However, this essential sector is confronted with a severe challenge in the form of the coconut whitefly, also known as *Aleurodicus cocois*, a pest that puts the health of crops and their output at risk. The effect of this disease goes beyond the immediate harm it does to the coconut palms; it also affects the livelihoods of farmers, the supply of coconut-based goods, and the price of those items, and it upsets the ecological balance that is necessary for sustain\able agriculture. The current circumstance shows the urgent need for creative and effective ways for pest control, such as the semiochemical-based strategy that was developed in this study.

The current strategies employed to combat the coconut whitefly in Sri Lanka are riddled with limitations. Chemical pesticides, the most common method, pose significant environmental hazards, threatening non-target species and potentially leading to the development of pest resistance. These chemicals also pose health risks to the farmers and consumers. Manual removal of the pests, while non-toxic, is impractical and labor-intensive, especially considering the scale of infestations and the height of mature coconut palms. Yellow sticky traps, another method, provide limited control and are ineffective in large-scale infestations. (Abeysekera, 2019).

This prevailing situation underscores the urgent need for an innovative, sustainable, and practical solution to manage the coconut whitefly menace effectively. The limitations of existing pest control methods highlight the necessity for a strategy that is not only environmentally responsible but also economically viable and easy to implement on a large scale. (Maniania and Ekesi, 2016).

The purpose of this study is to establish a unique approach of pest management that is both successful and ecologically sustainable and develop a semiochemical-based strategy, utilizing trunk injections, to manage the coconut white-fly infestation. This approach promises to be a targeted, environmentally responsible, and potentially more effective method compared to the current practices.

II.MATERIALS AND METHODOLOGY

A.Extraction of Plant Compounds

The extraction of insect repellent compounds was carried out using a systematic distillation method. Selected plant materials were placed into a distillation flask, and the distillation apparatus was set up according to proper guidelines. Distilled water was added to the flask, ensuring it covered three-fourths of the plant material to prevent overflow during boiling.

Upon heating the distillation flask, the water began to boil, releasing steam that carried the insect repellent compounds from the plant materials. The steam was then passed through a condenser, where it was cooled and converted back into a liquid. The resulting liquid consisted of a mixture of water and the extracted insect repellent compounds (Irzhad et al., 2023).

B.Isolation and Purification of Extracted Plant Compounds

The isolated plant compounds underwent a systematic isolation and purification process in the well-equipped laboratories of the Microbiology and Crop Science Departments at the Faculty of Technology, South Eastern University of Sri Lanka. Firstly, the extracted plant compounds were transferred to a separation funnel, where petroleum ether was added and thoroughly mixed. The mixture in the separation funnel was allowed to settle, resulting in two distinct phases: an upper organic phase (containing the plant compounds) and a lower aqueous phase (water). Sodium sulfate was then added to remove any residual water. The petroleum ether was subsequently evaporated using a rotary vacuum evaporator at 40°C. Once refined, the compounds underwent rigorous testing to determine their purity and concentration, ensuring that the pesticide formulation contained only the most effective and consistent components. This meticulous purification process is essential for developing a pesticide solution that is both effective and safe for managing the coconut whitefly (Skoog et al., 2013).

C. Preparation of Semiochemical Pesticides

The selected plant materials were dried to reduce their moisture content and then cut into small pieces. These were ground into a fine powder using a blender and placed into flasks. Hexane and methanol were added to the flasks as solvents, and the mixtures were shaken overnight at 1600 rpm. The polar and nonpolar compounds in the plant materials were extracted by the respective solvents. The resulting mixtures were filtered using filter papers, and the filtrates were collected in separate flasks for further analysis.

The final stage of this process involved homogeneously mixing all the pesticide compounds. Strychnos nux-vomica was identified as a promising compound. Additionally, neem oil, clove oil, and mint oil were incorporated. An ultrasonic mixing machine was used to ensure thorough mixing. The ultrasonic mixer effectively disperses nano-sized particles into liquids, such as water, oil, and solvents. Four types of formulations were prepared for mortality testing (McMurry, 2016).

Table 2.1: The percentages of **Strychnos nux-vomica, clove oil, mint oil,** and **neem oil** in each formulation.

Formulation	Strychnos nux-vomica	Clove oil	Mint oil	Neem oil
1	5%	5%	5%	5%
2	10%	5%	5%	5%
3	15%	5%	5%	5%
4	20%	5%	5%	5%

A. Tested the Efficacy of the Prepared Formulation Against Whitefly Through Laboratory Bioassays.

The pesticide was tested for its efficacy in controlling whiteflies through direct spraying prior to trunk injection. High-pressure spraying and mist spraying techniques were used to minimize fly dispersal and ensure effective application. Before spraying, the whitefly population on each sample was roughly counted. After spraying, the number of dead whiteflies was recorded at various time intervals, such as 10, 20, 30, 60, and 120 minutes. The treated leaf area remained free of whitefly infestation for approximately seven days following pesticide application.

B. *Trunk injection solution compounds*

During direct spraying, mortality was recorded positive way. Formulation of the highest mortality recorded, further incorporated with systemic carrier materials and tested for trunk injection. The first step of this process was the preparation of trunk injection formulations. Mainly four types of formulations were used.

Figure 01: Prototype trunk injector

Table 2.2: Components of Trunk injection formulations

Formulation	Components	Water (ml)	Pesticide
1	Citric Acid	40	Yes
2	Urea, KCl, and NaCl	40	No
3	Pesticide, Water, Citric Acid, and Salt	40	Yes
4	Pesticide, Citric Acid, and Salt	40	Yes

Drilled 3 inches and made two holes in the coconut trunk, and set a 20ml needle for each hole. Then pesticide and translocation mixture were inserted into each needles. Four coconut trees were used for four mixtures. Then monitored the absorption condition of the mixtures. All the mixtures were absorbed within one day.

Leaf samples were methodically collected at 2, 4, and 7 days post-application marking key intervals for evaluation. As well these collected samples were subjected to GC-MS analysis as per the procedure with the goal of evaluating the translocation design and the effectiveness of the mixtures along the trunk to the leaves over the specified time intervals.

VIII. RESULTS & DISCUSSION

A. *Evaluating Mortality Rates Induced by Formulated Semiochemical Pesticides*

Table 3 1: Formulation 1 mortality rate results

Plant 01 Sample Nos	Alive (before spray)	Alive (after spray)	Number of dead whiteflies
2	98	27	71
5	63	29	34
1	38	11	21
3	250	80	170
3.1	140	30	110
Total	589	177	406
			68.93%
	Morality rate		

The Table 01 illustrates that the number of coconut whiteflies that were alive before and after the application of formulation 1, along with the calculated mortality for each sample. The sum of white flies alive before the spray across all samples was 589, and the sum of those alive after the spray was 177. This resulted in a total of 406 dead. The mortality rate, presumably calculated as (Total dead / Total live before Spray) * 100, is approximately 68.93%. This indicates that, on average, about 68.93% of the coconut white flies were killed by formulation 1 across all the samples.

Table 3.2: Formulation 2 mortality rate results

Plant 02 Sample Nos	Live whiteflies (before spray)	Live whiteflies (after spray)	Number of dead whiteflies
18	338	19	319
10	178	7	171
12	244	0	244
10	156	12	144
Total	916	38	878
	Morality rate		95.85%

Sample No 18: Initially had 338 white flies alive, and after spraying, 19 remained alive, resulting in 319 mortalities. Sample No 10: Started with 178 white flies alive, with 7 surviving post-spray, leading to 171 mortalities. Sample No 12: Had 244 white flies before the spray, with none surviving afterward, thus 244 mortalities. Sample No 10: Had 156 were alive before the spray, and 12 remained after, resulting in 144 mortalities.

Summing up the figures, there were initially 916 white flies alive across all samples, and post-spray, 38 remained. This resulted in a total of 878 white flies being mortally affected by formulation 02.

The mortality rate for formulation 2 is calculated to be approximately 95.85%, as derived from the formula (Total dead/ Total Alive Before Spray) * 100. This suggests a very high efficacy of formulation 2 in causing mortality in the coconut whitefly population across the samples tested.

Table 3.3: Formulation 3 mortality rate results

Plant 03 Sample Nos	Alive (before spray)	Alive (after spray)	Number of dead whiteflies
7	38	4	34
8	89	3	86
16	106	13	93
18	208	14	194
Total	441	34	407
Morality rate			93.26%

The mortality rate for formulation 3 is calculated to be approximately 93.26%, as determined by the formula (Total dead/ Total Alive Before Spray) * 100. This rate suggests that Mixture 3 is highly effective, resulting in the death of a large majority of the coconut white-flies across the samples tested.

Table 3.4: Formulation 4 mortality results

Plant 04 Sample Nos	Live whiteflies (before spray)	Live whiteflies (after spray)	Number of dead whiteflies
2	197	4	193
6	141	8	133
3	69	13	56
10	268	11	257
Total	675	36	639
Morality rate			94.66%

The mortality rate for Formulation 4 is approximately 94.67%, calculated by the formula (Total dead / Total Alive Before Spray) * 100. This mortality rate is quite high, indicating that Formulation 4 is very effective in killing coconut white-flies across the tested samples.

Comparing formulations 4 to the previous formulations: Formulation 1 had a mortality rate of 68.93%, followed by Formulation 2 at 95.85% and Formulation 3 at 93.27%.Formulation 4's effectiveness is slightly less than that of Formulation 2 but is still considerably high and is more effective than Formulation 1 and slightly higher than Formulation 3. To determine the best mixture, one should consider not only the mortality rates but also factors such as environmental safety, cost-effectiveness, ease of application, and any non-target effects. Formulation 4 seems to be a strong candidate based on efficacy; however, a comprehensive evaluation including these additional factors is necessary for a conclusive decision.

IX. CONCLUSION

In conclusion, the experimental study on the effectiveness of different formulations for controlling coconut whiteflies in this preliminary study has shown promising results, especially with formulation 2 (10% Strychnos nux-vomica + 5% clove oil + 5% mint oil + 5% neem). oil) and formulation 4 (20% Strychnos nux-vomica + 5% clove oil + 5% mint oil + 5% neem oil). These formulations achieved high mortality rates of 95.85% and 94.67%, respectively, indicating their potential as effective pest control solutions. However, further research, including additional experiments and field trials, is essential to validate these results, ensure systemic properties of the coconut palm, and evaluate the effectiveness and sustainability in practice. The promising results of Formulations 2 and 4 highlight the need for further research to support their practical application in sustainable agricultural practices.

REFERENCES

Abeysekera, R. (2019). Business Development Services (BDS) offered by Microfinance Institutions (MFIs) in Sri Lanka: Case study as a research strategy. Sri Lanka Journal of Management Studies, 1(1), pp. 63–80.

Al-Ballaa, S.R. (2023). Curative treatment of red palm weevil, rhynchophorus ferrugineus (Olivier) in infested date palms using an innovative fumigation technique. Acta Horticulturae, (1371), pp. 111–120.

Arafa, O. (2021). Evaluation of the effectiveness of attractant trap colors on attractive red palm weevil, rhynchophorus ferrugineus (Olivier) in Egypt. Egyptian International Journal of Palms, 1(2), pp. 1–9.

Barnes, B.N. (2016). Sterile insect technique (sit) for fruit fly control – the South African experience. Fruit Fly Research and Development in Africa - Towards a Sustainable Management Strategy to Improve Horticulture, pp. 435–464.

Billah, M.K., and Wilson, D.D. (2016). Integrated management of Fruit Flies: Case Studies from Ghana. Fruit Fly Research and Development in Africa - Towards a Sustainable Management Strategy to Improve Horticulture, pp. 601–627.

Chandrasekaran, G., Subramanian, J., and Marimuthu, M. (2023). Volatile blooms of aleurodicus rugioperculatus Martin infested coconut and banana leaves attracting parasitoid Encarsia Guadeloupae Viggiani. Kufa Journal for Agricultural Sciences, 15(2), pp. 114–127.

Ekesi, S. (2016). Baiting and male annihilation techniques for fruit fly suppression in Africa. Fruit Fly Research and Development in Africa - Towards a Sustainable Management Strategy to Improve Horticulture, pp. 275–292.

Elango, K., and Jeyarajan, N.S. (2020). Population Dynamics of exotic rugose spiralling whitefly, Aleurodicus Rugioperculatus Martin (Hemiptera: Aleyrodidae) on coconut as influenced by weather factors and natural enemies. Journal of Plantation Crops, 48(2), pp. 120–125.

Elango, K., Arun Kumar, N., and Dhanasekar, V. (2022). Ovicidal and insecticidal effects of microbial pathogens against invasive coconut rugose spiralling whitefly (Aleurodicus rugioperculatus Martin) and impact on their chrysopid predator Mallada boninensis (Okamoto). Egyptian Journal of Biological Pest Control, 32(1), 1-9.

Fernando, N. A., and De Silva, S. (1988). An alternative development strategy for coconut smallholder sector in Sri Lanka. CORD, 4(01), pp. 34.

Ginanti, K.A., Wangsaputra, R. and Adriant, I. (2021a). Demand Chain Management Performance Assessment and strategy development of Virgin Coconut oil industry case study: Bumdes Bumi Lestari. Journal of Industrial Engineering Management, 5(1), pp. 50–55.

Gozel, U. and Gozel, C. (2016). Entomopathogenic nematodes in Pest Management'.Integrated Pest Management (IPM): Environmentally Sound Pest Management [Preprint].

Grundy, T. (2003).Value-added management development and training strategy. Value-based Human Resource Strategy, pp. 219–254.

Gunasinghe, C. (2015). An input-output modeling approach as an effective development strategy for Sri Lanka. Sri Lanka Journal of Economic Research, 3(2), pp. 3–30.

Hewage, A. (2014). Results based management: An approach for reducing regional disparities. Sri Lanka Journal of Development Administration, 4, pp.55.

Hussaini, S.S. (2014). Potential of entomopathogenic nematodes in integrated pest management. Integrated Pest Management, pp. 193–223.

Irzhad, M.P.M.,Kumara, A.D.N.T., and Mubarak A.N.M (2023). Combination of Organic Liquid Fertilizer and Sea Weed Extract Enhances the Tomato Growth, Yield and Photosynthetic Attributes Under Hydroponic System. Journal of the Bangladesh Agricultural University, 21(4), pp.406-413.

Kavithamani, V., and UmaMaheswari, S. (2023). Investigation of deep learning for whitefly identification in coconut tree leaves. Intelligent Systems with Applications, 20, pp. 200290.

Nandhini, D., and Srinivasan, T. (2022). Host range of coconut rugose spiralling whitefly aleurodicus rugioperculatus Martin. Indian Journal of Entomology, pp. 1–5.

Rathnaweera, D.U., and Weerakoon, K.G.P.K. (2021). Sustainability of urban recreational waterfront development in colombo urban area, Sri Lanka. Malaysian Journal of Society and Space, 17(4).

Skoog, D. A., West, D. M., Holler, F. J., & Crouch, S. R. (2013). Fundamentals of Analytical Chemistry. Brooks Cole.