The 4th International Seminar of Science and Technology
ISST 2024 Vol 4 (2025) 011
Innovations in Science and Technology to Realize Sustainable Development Goals
Faculty of Science and Technology
Universitas Terbuka

Applying Noni Leaf Extract to Spinach Plants as An Armyworm Control Method: A Review

Mar'atus Solikha, and Tuty Maria Wardiny*

Universitas Terbuka, Agribusiness Study Program, South Tangerang, Banten, Indonesia, 15437

Abstract - The armyworm (*Spodoptera frugiperda*) is a major pest of spinach, recognized for its hairless caterpillar form and propensity to attack in large numbers. Signs of infestation include torn leaves, irregular holes, and severe damage that often leaves only the veins and stems intact. Control strategies consist of preventive measures that involve removing and destroying eggs, caterpillars, or pupae on plants, and curative measures that utilize herbal pesticides, particularly a mix of noni leaf extract and wheat flour. The systematic literature review (SLR) aims to assess the potential of noni (*Morinda citrifolia*) leaf extract as a natural alternative to synthetic insecticides for controlling armyworm infestations in spinach cultivation. Noni leaves contain toxic compounds such as saponins and flavonoids, which disrupt armyworm development and can cause nerve damage, leading to suffocation. Regular monitoring is essential to assess the effectiveness of these control methods. The result showed that noni leaf extract can effectively reduce armyworm populations in spinach cultivation while minimizing harmful impacts on the environment and non-target organisms.

Keywords: armyworm, biopesticide, flavonoids, noni leaf extract, spinach plants

1 Introduction

Bioinsecticides are substances that manage agricultural pests by biological effects, rather than traditional chemical pesticides. Historically, synthetic pesticides have been effective in pest control and agricultural productivity[1]. Biocontrol products consist of natural organisms or compounds produced from natural sources, including animals, plants, microbes, and minerals including their genes or metabolites for managing insects [2]. Biopesticides often have various advantages over traditional insecticides. Pesticide residues in food pose a major health risk. Other risks include the development of resistance in target pest populations and reduced biodiversity. An advantage of microbial pesticides is that they replicate in their target hosts and persist in the environment due to horizontal and vertical transmission which may cause long-term suppression of pest populations even without repeated [3].

Spinach has significant antioxidants and polyphenols, and experimental investigations have shown that it protects against liver disorders. A case-control study of Iranian individuals sought to examine the relationship between dietary spinach intake and the risk of non-alcoholic fatty liver disease (NAFLD) [4]. Public demand for mustard and spinach is always growing, while mustard and spinach output in Ambon City remains relatively low. Pest attacks, particularly leaf caterpillars (*Plutella xylostella)* on mustard plants and leaf caterpillars (*Spodoptera plusia hymenia*) on spinach

*Corresponding author: tuty@ecampus.ut.ac.id

plants, are one reason contributing to low productivity. Pest and pathogen attacks cause crop loss and lower yield quality, hence they must be managed [5]. Farmers commonly employ pesticides to preserve the quality and quantity of vegetable output. The biggest issue with the incorrect usage of pesticides is the presence of residues in vegetable products [6].

Abdulrasheed stated that qualitative phytochemical screening assays are an essential technique in bioactive compound analysis because they are affordable, rapid, and easy procedures that give researchers an immediate understanding of the phytochemical components in a plant extract [7]. This method employs established and specific assays to demonstrate the presence of a specific substance. The key processes in identifying and utilizing plant-based biologically active chemicals are extraction, screening, and characterization, followed by toxicity evaluation. This study aimed to extract and determine bioactive components such as tannins, steroids, saponins, flavonoids, and alkaloids in *M. citrifolia* leaf powder using a phytochemical screening assay (chemical testing). The results indicated the presence of alkaloids, steroids, tannins, carbohydrates, terpenoids, glycosides, and flavonoids in both leaves. Furthermore, several secondary metabolites were found in different organic solvents, showing that *M. citrifolia* includes bioactive chemicals with potential medical uses [8].

There is no research on using noni leaves (*Morinda citrifolia*) as a biopesticide against the spinach armyworm (*Spodoptera litura*). Noni fruit extracts have been shown to effectively suppress *Spodoptera litura* in other crops such as cabbage and mustard, but research on noni leaves for spinach has yet to be undertaken. This gap presents an opportunity for future research to explore the potential of noni leaves in pest management for spinach cultivation [9].

2 Materials and Methods

The methodology used in this article is a structured and comprehensive approach to reviewing existing research on a particular topic. It aims to synthesize findings from multiple studies to provide a clear understanding of the current state of knowledge, identify gaps, and inform future research. The primary purpose of an SLR is to provide a comprehensive overview of existing literature on a specific topic, enabling researchers to Identify trends and gaps in research, Assess the strength of evidence regarding specific interventions or phenomena, Inform clinical practice or policy decisions based on synthesized evidence. By adhering to a systematic approach, SLR minimizes bias and enhances the reliability of conclusions drawn from the body of literature being reviewed.

3 Results and Discussions

3.1 Phytochemicals *Morinda citrifolia*

Noni leaves, derived from the plant *Morinda citrifolia*, have garnered attention for their potential as biopesticides due to their rich content of bioactive compounds. Noni leaves contain several phytochemicals that contribute to their efficacy as biopesticides (1) Alkaloids: These compounds are known for their toxicity to various pests, making them a primary focus in biopesticide development. Present at concentrations of approximately 2.82% (2) Flavonoids: exhibit various biological activities, including antimicrobial properties. (3) Terpenoids and Steroids: These compounds also contribute to the overall effectiveness of noni leaves in pest management. The extraction process is crucial for isolating the active compounds. High water content in fresh leaves can hinder effective extraction, thus necessitating proper drying methods [10]. The extracts contain various active compounds, including flavonoids (approximately 2.82%) and alkaloids, which contribute to their

insecticidal properties [11]. A study indicated that a 20% ethanol extract of noni leaves was highly effective in killing both standard and field populations of German cockroaches. This concentration also showed significant repellent properties against these pests. Sub-lethal concentrations of 0.36% and 1.08% were noted as effective repellents without significantly inhibiting food consumption in the cockroach population [12]. Those extracts are also tested for efficacy against specific pests. For instance, a study demonstrated that a 37.5% concentration of noni leaf extract effectively repelled *Aedes aegypti* mosquitoes, achieving an average protection rate of 90.86% over six hours [13].

The pricing of synthetic insecticides often dictates market dynamics. If synthetic options are significantly cheaper, it may pressure the pricing of biopesticides unless their benefits are communicated to consumers. However, the growing demand for environmentally friendly pest control solutions can drive prices up. As consumer awareness increases, the willingness to pay for natural alternatives may enhance the economic viability of noni-leaf biopesticides [14]. The particle size of noni leaves significantly affects the efficiency of biopesticide extraction, influencing the yield and concentration of active compounds. Smaller particle sizes increase the surface area available for solvent interaction during the extraction process. This enhanced surface area facilitates better penetration of the solvent into the plant material, leading to higher extraction yields of bioactive compounds such as flavonoids and alkaloids [23].

3.2 Correlation with Antioxidant Activity

The antioxidant activity of noni leaf extracts is closely linked to the concentration of specific phytochemicals like flavonoids and phenolics as particle size decreases, the extraction efficiency increases, resulting in higher concentrations of these compounds and thus stronger antioxidant properties of the Ferric Reducing Antioxidant Power (FRAP) method yielded results for the antioxidant activity ranging from 5535.31 ± 37.48 to 312014.20 ± 2397.19 mmol TE/100 g (equivalent to Trolox) and 129785.30 ± 2397.19 to 467970.40 ± 5085.25 mmol AA/100 g (equivalent to ascorbic acid). Notably, the lyophilized pulp powder demonstrated the highest antioxidant activity among the aqueous extracts, with 312014.20 ± 2397.19 mmol TE/100g and 467970.40 ± 5085.25 mmol AA/100g, respectively. Ethanolic extracts were followed by acetone at 80% and acetone at 70% [15]. For further information, please view Fig. 1.

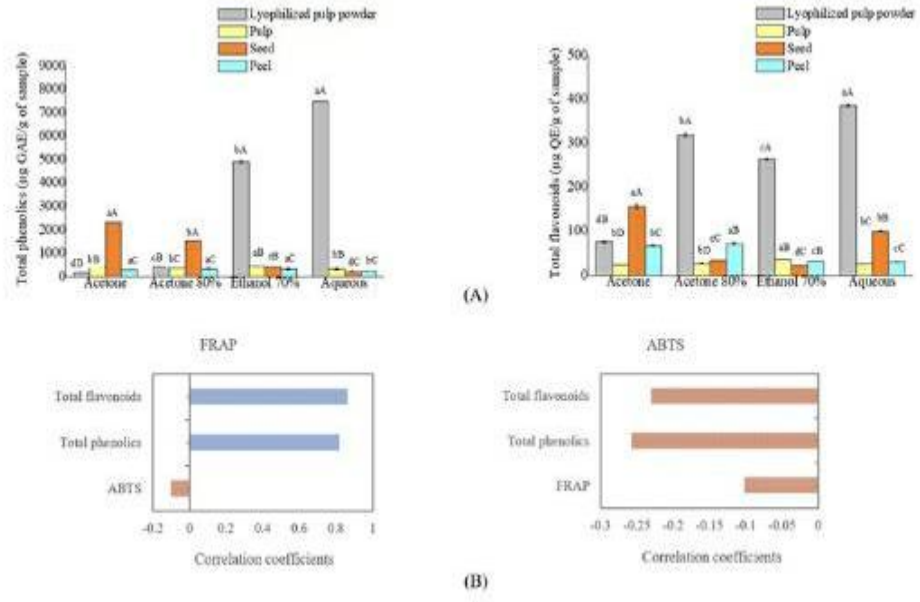

Fig. 1. Contents of total phenolics and flavonoids in noni pulp, seed, peel, and lyophilized pulp powder (A) and antioxidant activity correlation between FRAP and ABTS (B) [15].

3.3 Impact on Specific Phytochemicals and Extraction Techniques

3.3.1 Impact of Particle Size on Extraction Efficiency

Prasedya, studies indicate that reducing the particle size improves the extraction yield. For instance, finer particles (less than 45 µm) have been shown to yield a greater concentration of phytochemicals compared to larger particles. This is attributed to the more efficient release of compounds into the solvent. The effectiveness of solvents in extracting active compounds is enhanced with smaller particle sizes. This results in a more efficient extraction process, as the solvent can more readily access and dissolve the desired phytochemicals. Smaller particles may also reduce the time required for extraction. Since the solvent can interact more effectively with a larger surface area, less time may be needed to achieve optimal extraction compared to coarser materials. Smaller particles may also reduce the time required for extraction. Since the solvent can interact more effectively with a larger surface area, less time may be needed to achieve optimal extraction compared to coarser materials. The method of preparing noni leaves (such as drying and grinding) plays a crucial role in determining particle size. Consistent grinding techniques should be employed to achieve a uniform particle size that optimizes extraction efficiency [16]. The method of preparing noni leaves (such as drying and grinding) plays a crucial role in determining particle size. Consistent grinding techniques should be employed to achieve a uniform particle size that optimizes extraction efficiency. reducing the particle size of noni leaves enhances the efficiency of biopesticide extraction by increasing surface area, improving extraction yields, and potentially shortening extraction times. These factors contribute to obtaining higher concentrations of active compounds, making it essential to consider particle size in the production process of noni-leaf biopesticides [10].

3.3.2 Impact on Extraction Techniques

Phytochemicals like flavonoids and tannins contribute significantly to antioxidant activity and are more efficiently extracted from smaller particles. The correlation between higher concentrations of these compounds and increased antioxidant capacity indicates that optimizing particle size is crucial for maximizing health benefits. Techniques such as ultrasonication combined with enzymatic treatment can further reduce particle size and improve extraction efficiency, leading to higher bioactive compound yields and enhanced antioxidant properties in noni-juice in [17][18] in [11] [19].

3.3.3 Extraction through the Fermentation Process

The fermentation of soursop and noni leaves using *Lactobacillus plantarum* BP10 significantly enhances their antioxidant activity by increasing the levels of phenolic compounds and flavonoids. This biotechnological approach not only improves the health benefits associated with these plants but also opens avenues for their application in functional foods and nutraceuticals aimed at combating oxidative stress-related diseases. Further studies are encouraged to optimize fermentation conditions and explore the full potential of these fermented extracts in various health applications [20].

3.3.4 The utilization of noni leaves extract to cure ailments in spinach

Research indicated that noni leaf extract can achieve substantial mortality rates in *S. litura*. A study found that a concentration of 5% resulted in a mortality rate of 75.40% after treatment, demonstrating the potential of noni as a natural pesticide. The active compounds in noni leaves may interfere with the growth and development of the larvae, inhibiting their ability to transition from one life stage to another. This disruption is crucial in controlling pest populations as it reduces the number of adults that can reproduce [14]. Further studies have shown that increasing the concentration of noni leaf extract enhances its effectiveness. For instance, a concentration of 25% was found to kill up to 87% of the larvae, significantly reducing their ability to develop into pupae and adults. This concentration also effectively decreased the feeding activity of the larvae by approximately 86%. Noni leaf extract has been shown to reduce the feeding activity of *S. litura*. At higher concentrations, it can decrease feeding by approximately 86%, which not only contributes to larval mortality but also affects their growth and development, leading to fewer larvae reaching the pupal stage. The LC50 (lethal concentration for 50% of the population) value was determined to be around 23%, indicating the potency of the extract. The relationship between extract concentration and mortality is clear; higher concentrations lead to increased mortality rates. In various studies, concentrations ranging from 1% to 25% were tested, with higher concentrations consistently yielding better results in controlling *S.litura* populations [21]. Applying the extract at the right time, such as when the larvae are still young and actively feeding, can enhance effectiveness. Observations indicate that the application of botanical pesticides is more effective when done during the early instar stage of the larvae Application methods such as thorough spraying on the upper and lower surfaces of the leaves can ensure that the larvae are adequately exposed to the extract. Spraying during favorable weather conditions (for example, not too hot or windy) can also enhance absorption and effectiveness [9].

4 Conclusion

Utilizing noni leaf extract as a botanical pesticide can effectively reduce the armyworm population in spinach cultivation while minimizing harmful impacts on the environment and non-target organisms.

References

[1] J. F. Barrera and J. F. Barrera, "Theoretical support of holistic pest management," *Beyond IPM: Introduction to the Theory of Holistic Pest Management*, pp. 47–70, 2020.
[2] B. C. Nwachukwu, O. O. Babalola, and A. I. Hassen, "Rhizosphere competence and applications of plant growth-promoting rhizobacteria in food production-a review," *Sci Afr*, p. e02081, 2024.
[3] A. K. Chakravarthy, "*Innovative pest management approaches for the 21st century: Harnessing automated unmanned technologies*," Springer, 2020.
[4] E. Mokhtari *et al.*, "Spinach consumption and nonalcoholic fatty liver disease among adults: a case-control study," *BMC Gastroenterol*, vol. 21, no. 1, p. 196, 2021.
[5] C. M. A. Wattimena and F. S. Latumahina, "Effectiveness of botanical biopesticides with different concentrations of termite mortality," *J. Belantara*, vol. 4, pp. 66–74, 2021.
[6] R. F. Suneth, D. Dadang, and A. Nurmansyah, "Residues of several active insecticide ingredients in spinach (*Amaranthus tricolor* L.) and kale (*Ipomoea reptans* (L.) Poir.) in Bogor, West Java," in *BIO Web of Conferences*, EDP Sciences, 2024, p. 04002.
[7] H. H. Abdulrasheed, M. Akilu, and M. Mohammed, "Phytochemical analysis of Daucus carota and Zingiber officinale samples collected from Gwarimpa Abuja Nigeria," *Journal of Diseases and Medicinal Plants*, vol. 4, no. 2, 2020.
[8] S. A. Shettima, A. A. Baffa, O. B. Uzoma, A. K. Akinlabi, and A. A. Shettima, "Investigation into the potential uses of noni (*Morinda citrifolia*) leaves and stem bark," *Journal of Chemical Society of Nigeria*, vol. 48, no. 2, 2023.

[9] B. Anes, J. Manueke, and B. V Montong, "Potensi buah mengkudu, *Morinda citrifolia* L. sebagai insektisida nabati dalam mengendalikan hama *Spodoptera litura* F. pada tanaman kubis, *Brassicae oleracea* L. di Kota Tomohon," *JURNAL ENFIT: Entomologi dan Fitopatologi*, vol. 2, no. 1, pp. 16–23, 2022.

[10] B. Santoso, S. Haryati, R. R. Santoso, and M. F. A. Syakura, "Effect of various drying methods against biopesticide product from noni leaves extraction," *Chem Eng Trans*, vol. 104, pp. 187–192, 2023.

[11] W. Setyani and H. Setyowati, "Phytochemical investigation of noni (*Morinda citrifolia* L.) leaves extract applicated for sunscreen product," *Mal. J. Fund. Appl. Sci*, vol. 14, pp. 164–167, 2018.

[12] R. Rahayu, A. P. Suryadini, H. Herwina, and R. Jannatan, "Research article efficacy of noni (*Morinda citrifolia* L.) ethanolic leaf extract against German cockroach (*Blattella germanica* L.)," 2021.

[13] D. Nurmayanti, L.Fithriyah, Ngadino, I. Sulistio, S. Wardoyo, Marlik, M.Setiawan, Potential of noni leaf extract (*Morinda citrifolia* L.) as *Aedes aegypti* mosquito repellent," *Media Kesehatan Masyarakat Indonesia*, vol. 20, no. 1, pp. 11–19, 2024.

[14] B. A. Luqman and Y. Yuliani, "Efektifitas ekstrak campuran daun mengkudu (*Morinda citrifolia* L.) dan bintaro (*Cerbera odollam*) terhadap mortalitas *Spodoptera litura* F.," *LenteraBio: Berkala Ilmiah Biologi*, vol. 12, no. 2, pp. 179–185, 2023.

[15] R. F. Fontes, J. K. S. Andrade, M. Rajan, and N. Narain, "Chemical characterization of different parts of noni (*Morinda citrifolia*) fruit and its freeze-dried pulp powder with emphasis on its bioactive compounds and antioxidant activities," *Food Science and Technology*, vol. 43, p. e103722, 2023.

[16] E. S. Prasedya, A. Frediansyah, N. W. R. Martyasari1, B. K. Ilhami1, A. S.Abidin1, H. Padmi, Fahrurrozi, A. B. Juanssilfero, S. Widyastuti & A. L. Sunarwidhi "Effect of particle size on phytochemical composition and antioxidant properties of *Sargassum cristaefolium* ethanol extract," *Sci Rep*, vol. 11, no. 1, p. 17876, 2021.

[17] L. Meilawati, T. Ernawati, R. T. Dewi, M. Megawati, and S. Sukirno, "Study of total phenolic, total flavonoid, scopoletin contents and antioxidant activity of extract of ripened noni juice," *Indonesian Journal of Applied Chemistry*, vol. 23, no. 2, pp. 55–62, 2021.

[18] F. A. Mubarokah, W. Yuliasari, and T. S. Wibowo, "Phytochemical screening of noni (*Morinda citrifolia* L) leaf ethanol extract in Pejagan Village, Bangkalan Regency," *Indonesian Journal of Interdisciplinary Research in Science and Technology*, vol. 1, no. 7, pp. 661–668, 2023.

[19] Z. Wang *et al.*, "In vitro antioxidant activity of *Moringa oleifera* Lam. leaf after *Monascus purpureus* fermentation and chemical component changes by untargeted metabolomics," *LWT*, p. 116723, 2024.

[20] R. E. Putri, N. R. Mubarik, L. Ambarsari, and A. T. Wahyudi, "Antagonistic activity of glucanolytic bacteria *Bacillus subtilis* W3. 15 against *Fusarium oxysporum* and its enzyme characterization," *Biodiversitas*, vol. 22, no. 9, 2021.

[21] S. Salessy, A. Awan, and S. Wael, "Effectiveness of soursop leaf extract (*Annona muricata* L) on the mortality of graycool caterprises (*Spodoptera litura*)," *RUMPHIUS Pattimura Biological Journal*, vol. 4, no. 1, pp. 26–33, 2022.