



## **Utilization of neem trees (*Azadirachta indica*) as biopesticide from ancient India to Indonesia: an ethnographic study based on literature review**

**Muhammad Arif Rahman<sup>1,2\*</sup>, Sholeh Hidayat<sup>1</sup>, Ujang Jamaludin<sup>1</sup>, Suroso Mukti Leksono<sup>1</sup>**

<sup>1</sup>*Doctoral Program of Education,, Universitas Sultan Ageng Tirtayasa, Indonesia*

<sup>2</sup>*Banten Province Human Resources Development Agency, Indonesia*

\*E-mail: [yamakawa.uip@gmail.com](mailto:yamakawa.uip@gmail.com)

(Received: 13 June 2023; Accepted: 20 August 2023; Published: 31 August 2023)

### **ABSTRACT**

One of the biopesticides is derived from The Neem Tree (*Azadirachta indica*), which has been widely used in India for centuries. The purposes of this study are to examine the historical use of neem trees as biopesticides in ancient India, the adoption and integration of neem tree-based biopesticides in Indonesian agriculture, the cultural and historical context of neem tree use, and the impact of neem tree-based biopesticides on sustainable agriculture. The research design for this study is an ethnographic approach, which involves the systematic observation, documentation, and analysis of the cultural practices and beliefs related to using neem trees as biopesticides. The findings of this study demonstrate that the Neem tree has been widely described as a biopesticide used to control pests in agriculture in ancient Indian literature, such as the Rigveda and Atharvaveda. The neem tree held cultural and spiritual significance in ancient Indian society, associated with deities and religious beliefs. Historical connections between India and Indonesia facilitated the spread of neem tree-based biopesticides to Indonesia, where they were adopted and integrated into traditional agricultural practices. Indonesian farmers embraced neem tree-based biopesticides and recognized their efficacy in pest control, contributing to sustainable agricultural practices.

**Keywords:** Biopesticide, ethnographic study, neem trees,

**DOI:** [10.30870/gravity.v9i2.20454](https://doi.org/10.30870/gravity.v9i2.20454)

### **INTRODUCTION**

Natural biopesticides have gained popularity in agricultural techniques due to their environmental sustainability and potential health advantages. One such biopesticide is generated from the neem tree, which has been used for centuries in India. The neem tree, which originated from the Indian subcontinent, has long been revered for its medicinal and pesticidal features. Koul (2004) stated that the subject origin of Neem Tress is still controversial,

Roxburgh in Koul said that its origin in Myanmar, and Varthak and Ghate in Koul stated that the origin of neem trees was in Karnataka, in part of South India. According to Kumar (2013), Neem is an all-powerful tree and a precious gift from nature, the mahogany family called Meliaceae. The neem tree was vital in ancient India in agriculture and healthcare systems.

References to the use of neem as a biopesticide (Bajwa & Ahmad, 2012) and medicinal plant can be found in ancient Indian texts, including the Rigveda, Atharvaveda, Charaka Samhita, Sushruta Samhita, and Manusmriti. These texts provide insights into the traditional knowledge, practices, and cultural significance associated with the neem tree. South Indians identify the Goddess Marimman with neem trees. This Goddess is responsible for causing and curing skin diseases such as smallpox (Pullaiah et al., 2018). Over time, the knowledge and practices related to neem tree and its biopesticidal properties spread beyond India's borders, including Indonesia. During the Hindu kingdom era in India, especially from the 4th to the 15th century CE, the relationship between India and Indonesia was strong. India was a center of Hindu culture and spirituality, and its influence extended to various regions, including Indonesia. Indonesia has historical connections with India, which facilitated the exchange of religion, social culture, and agricultural practices and knowledge.

There were lots of studies about the use of Neem Trees as biopesticides, and it's classified into the general knowledge about Neem trees, such as Properties of the neem tree (Schmutterer, 1990), Neem as modern natural pesticides (Morgan, 2006), and Perspective of Neem (Koul, 2004). The effects of Neem Trees (Ascher, 1993) as Biopesticides (Weathersbee & McKenzie, 2005); (Grisakova et al., 2006); (Debashri & Tamal, 2012), (Mohammed & Idriss, 2023). The Potential and Prospect of Neem Trees as Biopesticides (Bajwa & Ahmad, 2012), Prospects of Neem Trees as Pest Control (Asogwa et al., 2010); (Khater, 2012); (Dimetry, 2012), Neem in Agriculture (Acharya et al., 2017). The Products and The Derivations of Neem Trees (Taylor & Gahukar, 2010); (Boadu et al., 2011); (Lokanadhan et al., 2012) and (Roychoudhury, 2016). The risk of using neem trees as biopesticides (Rosenkranz & Klopman, 1995), Evaluation of neem as pesticides (Boeke et al., 2004), (Pandey et al., 2014) and (Goktepe et al., 2004).

A wide variety of research on neem trees as a biopesticide focused on the product, impact, and efficacy of neem leaves as a biopesticide. However, there has been little research on ethnographic studies of neem leaves, such as Etnobotani in India (Pullaiah et al., 2018). As a result, the author will conduct an ethnographic study involving literature searches and interviews with different farmer groups and agriculture-related organizations in Indonesia to investigate the application of biopesticides in Banten Province. The adoption and integration of neem tree-based biopesticides in Indonesian agriculture have likely influenced traditional knowledge and practices in the country. Despite the historical importance and widespread use of neem tree-based biopesticides, there is a need for an in-depth ethnographic study to explore the historical background, cultural significance, and knowledge transmission related to neem tree use.

By conducting a literature review of relevant texts, this study aims to shed light on using neem trees as biopesticides from ancient India in Indonesia, providing insights into traditional agricultural practices, cultural beliefs, and sustainability. Understanding the historical context and traditional techniques associated with using neem tree-based biopesticides can help preserve and promote sustainable agriculture methods. Moreover, examining the knowledge transfer from ancient India to Indonesia can help identify challenges and potential opportunities

for utilizing neem tree-based biopesticides in modern agricultural systems.

The objectives of this study are 1) to examine the historical use of neem tree as biopesticides in ancient India, including references in ancient texts, traditional practices, and cultural significance, 2) to investigate the adoption and integration of neem tree-based biopesticides in Indonesian agriculture, exploring the historical connections between India and Indonesia, traditional knowledge transfer, and its impact on agricultural practices, 3) to analyze the cultural and historical background of neem tree use, discovering connections and contrasts in traditional practices and knowledge in ancient India and Indonesia, 4) to evaluate the impact of neem tree-based biopesticides on sustainable agriculture, considering its environmental benefits, human health implications, and potential for promoting eco-friendly farming practices.

Overall, this research is significant as it contributes to understanding the historical and cultural dimensions of neem tree use as biopesticides, promoting sustainable agricultural practices, and facilitating the exchange of knowledge and experiences between different agricultural communities.

## **RESEARCH METHODS**

The research design for this study is an ethnographic approach, which involves the systematic observation, documentation, and analysis of the cultural practices and beliefs related to using neem trees as biopesticides in ancient India and their spread to Indonesia. A qualitative technique is used in this investigation. This method uses participant observation, meaning the researcher is the data-collecting tool (Sugiyono, 2018). Ethnography allows for an in-depth exploration of the cultural and historical dimensions of the topic, providing a holistic understanding of the subject matter. Literature search and selection of relevant texts: This study's primary data collection method is a comprehensive literature review. The researcher will extensively search relevant literature, including academic articles, books, research papers, historical texts, and other relevant sources. The literature search will encompass Indian and Indonesian literature to ensure a comprehensive understanding of the topic. Extraction and analysis of information:

After selecting the relevant texts, the researcher will extract the necessary information about using neem trees as biopesticides in ancient India and their adoption in Indonesian agriculture. Essential information such as historical references, traditional practices, cultural significance, and knowledge transfer will be identified and documented for further analysis by conducting interviews with the traditional farmers of Baduy Tribes, The Group of Farmers (Gapoktan), and the civil apparatus in charge of plant pest control at the Banten Provincial Agriculture Department. Interviews are a standard method used in ethnography. This method collects more detailed information from respondents or study informants. Interviews are essentially dialogues between researchers and informants to gather specific information (Manan, 2021).

## RESULTS AND DISCUSSION

### **Neem Tree as Medicine and Biopesticides in Ancient Indian Literature:**

Neem Tree is identified as "arista" in Sanskrit, which signifies flawless, whole, and imperishable. In India, the tree is regarded as the local medical facility (Vithalkar et al., 2023). Overview of references and knowledge in ancient texts: The findings reveal that ancient Indian texts, such as the Rigveda, Atharvaveda, and other literary works, reference the neem tree and its biopesticidal properties. Many advantages of neem are documented in ancient texts such as the *Charak Samhita* and *Susruta Samhita*. It is also known as 'Indian Lilac' or 'Margosa'.(Pandey et al., 2014). Kumar & Navaratnam (2013) stated that One of the world's oldest medical systems is Siddha medicine. Neem or margosa was the first medicinal plant described in the annals of the ancient Siddha school of medicine and in ancient Tamil literature.

Since time immemorial, humankind has used neem as a deterrent against smallpox and other contagious diseases, and it is also said to have the capacity to ward off bad spirits (Kumar & Navaratnam, 2013). The findings suggest that the neem tree held cultural and spiritual significance in ancient Indian society. It was revered as a sacred tree associated with deities and religious beliefs. The cultural and spiritual value attributed to the neem tree further emphasized its importance and the holistic approach to its use as a biopesticide. We would expect botanical pesticides to be a staple in farmers' plant protection arsenals in India, given the country's 2000-year history of using neem (*Azadirachta indica*) for medicinal uses and stored-product protection (Isman, 2015). These practices demonstrate the long-standing knowledge and application of neem tree biopesticides in ancient Indian agricultural systems.

### **Adoption and Integration of Neem Tree in Indonesian Agriculture:**

The findings indicate that historical connections between India and Indonesia played a role in adopting and integrating neem tree-based biopesticides in Indonesian agriculture. Trade, cultural exchanges, and maritime links facilitated the transfer of knowledge and practices related to the neem tree from India to Indonesia. Lawler covers the evolution of the Indian Ocean commerce from the 5th to the 8th centuries C.E. According to the map (p.1441), Indonesia and the islands of Southeast Asia joined these networks in the eighth century C.E. Archaeological evidence from the Indonesian islands of Bali, Java, and Sumatra indicates that marine commerce in this region began 900 years earlier (Calo, 2014).

The findings highlight the utilization and benefits of neem tree-based biopesticides in Indonesian agriculture. Indonesian farmers have recognized the efficacy of neem tree extracts in pest control and have incorporated them into their pest management strategies. Agriculture in Indonesia has developed into the use of neem as a biopesticide. Elvira (2023) studied the Utilization of Neem Leaves as a Biological Pesticide for the Control of Anthracnose Diseases in Dragons (*Hylocereus* sp.), and Ayini et al. (2014) studied Neem Leaf Extract. The natural properties of neem tree-based biopesticides, such as insecticidal and repellent effects, have provided benefits in terms of pest suppression and reduced reliance on synthetic pesticides. Adopting neem tree-based biopesticides aligns with sustainable agriculture practices and contributes to environmentally friendly pest control methods.

### **Cultural and Historical Context of Neem Tree Use:**

The research findings reveal that the neem tree holds significant cultural and historical importance in ancient India and Indonesia. In ancient Indian culture, the neem tree is considered sacred and is associated with various deities and religious rituals. Tiwari & Chaudary (2019) stated that Goddess Sitala Devi is said to exist in this tree in Hindu tradition. There are several examples of tree worshiping throughout the Harappan civilization. The Indian society stressed tree worship and created various natural representations like gods and goddesses. Indians revered natural bodies such as the Sun, Moon, Earth, rivers, and many plants. They respected natural things because they realized they couldn't live without them. The environment provided humans with food and shelter. Because our forefathers recognized the importance of trees, they not only conserved them but also praised them (Pandey et al., 2014).

Similarly, in Indonesian culture, the neem tree is recognized for its medicinal and spiritual properties. According to Sukarsno (2003), most neem trees in Indonesia are planted in Bali. More than 500,000 trees have been planted. The neem tree is known as Intaran in Bali. This plant is deeply ingrained in the Balinese culture.

### **Impact of Neem Tree Use on Sustainable Agriculture:**

The research demonstrates that using neem tree as a biopesticide positively impacts sustainable agriculture. These trees are native to Asia's tropical and subtropical climates, because of their remarkable climate endurance, they are currently cultivated in various warm locations of the world. (Debashri & Tamal, 2012). Neem tree-based biopesticides offer an eco-friendly alternative to synthetic pesticides, reducing the dependence on harmful chemicals and minimizing adverse environmental effects. The natural properties of neem tree extracts, such as azadirachtin, provide effective pest control while being biodegradable and posing minimal risks to non-target organisms. The study emphasizes that adopting neem tree-based biopesticides promotes sustainable agricultural practices by maintaining ecological balance and preserving soil and water quality.

### **Challenges and Future Prospects:**

The research identifies several challenges and prospects related to neem tree use as biopesticides. Challenges include limited access to neem tree resources, variations in extraction methods and quality control, and farmers' need for awareness and capacity building. Additionally, there is a need for further scientific research to validate the efficacy (Debashri & Tamal, 2012) and safety of neem tree-based biopesticides (Boeke et al., 2004) and to develop standardized protocols for their preparation and application. The study suggests that overcoming these challenges can pave the way for the broader adoption of neem tree-based biopesticides and the integration traditional knowledge with modern agricultural practices, thereby enhancing sustainable pest management strategies.

### **Overview of Neem Tree (*Azadirachta indica*)**

Neem is a vast, resilient, evergreen tree native to the Indian subcontinent. (Gajalakshmi & Abbasi, 2004).



**Figure 1.** The neem trees

Because of its numerous uses, neem has earned the nickname "wonder tree." Besides its medical characteristics, neem has already established its utility as a natural source of insecticides, pesticides, and agrochemicals. Because synthetic insecticides have severe environmental effects, the need for ecologically acceptable alternative pest controls for agriculture has pushed pest-control specialists to return to the plant world as a source of pesticides. (Brahmachari, 2004).

**Table 1.** Taxonomy of neem trees (*azadirachta indica*)

No	Taxonomy	Description
1	Kingdom	Plantae
2	Sub-Kingdom	Tracheobionta
3	Division	Magnoliophyta
4	Class	Eudicot
5	Sub-Class	Rosidae
6	Order	Sapindales
7	Family	Melilaceae
8	Genus	Azadirachta
9	Species	Azadirachta Indica

The neem tree is a medium to large-sized tree that can grow up to 12 - 18 meters in height. It has a dense, spreading crown and a thick, rough bark. The leaves are compound, pinnate, and alternate, with 20-31 leaflets and 8-19 cm long. The leaflets are lanceolate or oblong, and their arrangement gives the foliage a feathery appearance. The stem is 1.8 to 2.4 metres, and the wood is dark grey and reddish brown. The seed's diameter is 1-2 cm and can grow better on 5 – 8.5 pH range, 400-1200 yearly rainfall, 21-32 °C temperature, and 1.850 above sea level. The neem tree produces small, white, fragrant flowers arranged in clusters called panicles. The fruits

are olive-like drupes that are green when young and turn yellow or brown as they mature.

**Physical Properties of Neem Tree (*Azadirachta Indica*)**

**Table 2.** Physical properties of *Azadirachta indica*

No	Physical Properties	Description
1	Trees Height	12 – 20 metres tall
2	Leaves Length	8 – 19 cm
3	Stem Wide	1.8 – 2.4 metres
4	Type of Woods	Hard and woody
5	Colors of wood	Dark Grey and Reddish Brown
6	Seeds diameter	1 – 2 cm diameter
7	Growth Temperature	21-32 °C
8	Sea Level	1850 above sea level

**Historical Significance and Traditional Uses:**

The neem tree holds immense historical significance in various cultures, particularly India. It has been called the "*Village Pharmacy*" due to its wide range of medicinal properties and traditional uses. In India, the tree is known as "Sarbaroganibarini," which refers to the "reliever of all diseases," and it is known as the "village dispensary." Ayurveda, Siddha, Unani, Amchi, and other indigenous healing systems have around 700 herbal treatments based on neem (Brahmachari, 2004). The various parts of the neem tree, including leaves, bark, seeds, and oil, have been used for centuries in traditional medicine and Ayurvedic practices. In traditional Indian medicine, Neem has been used to cure various conditions, including skin diseases, digestive troubles, respiratory issues, and infections. Neem leaves have been used to make poultices, pastes, and decoctions to treat skin conditions like acne, eczema, and fungal infections. Neem oil, extracted from the seeds, has been used topically for its antimicrobial and anti-inflammatory properties.

**Spread of Neem Tree and its Biopesticidal Properties to Indonesia**

India and Indonesia have long cultural, trade, and maritime connections. These historical links facilitated knowledge exchange, including agricultural practices and plant species. The neem tree and its biopesticidal properties likely spread to Indonesia through these connections as traders, scholars, and travelers traversed the Indian Ocean. According to Sarumaha (2022), Neem leaf extracts are efficient against 127 different pests and may be used as fungicides, bactericides, antivirals, nematicides, and molluscicides. Various phytochemical components found in neem leaf extracts, such as alkaloids, tannins, and flavonoids, impact digestion and disrupt metabolism in insects, leading them to die.

### **Impact on Traditional Knowledge and Practices:**

Using neem tree-based biopesticides in Indonesian agriculture has affected traditional knowledge and practices. Farmers in Indonesia have adopted neem tree-based pest management methods in their pest management strategies, in addition to their traditional indigenous approaches. Using neem tree-based biopesticides may have resulted in the transfer of neem tree-related knowledge and practices from India to Indonesia. Local farmers may have altered and localized the procedures to meet the needs of their agricultural areas and crop varieties.

Interviews were done with local farmers by the author. Iman is from the "Baduy Luar" village in Ciboleger Lebak, Indonesia. The author questioned their traditional farming approach and the biopesticides they use. Chemical pesticides, he said, are not authorized in Baduy culture since they are destructive to the environment. Several plants, including "Babadotan Trees," Chilli, and Garlic, are used as biopesticides, and they combine 3 - 5 random trees from surrounding their farm to be used as biopesticides, but they do not mention neem trees. They believed that neem trees could have another name in Baduy. Those assertions are supported by Saenong (2017), who argues that Indonesian plants with bioinsecticidal potentials, such as lemongrass, Red Onion, Garlic, Dringo (*Acorius calamus*), Babandotan (*Ageratum conyzoides*), Red Chilli, Neem Trees, Pepper, Cloves, Aromatic ginger and so on.

The author also interviewed a group of farmers (Gapoktan) Sukaratu in Cikeusal District, Serang Banten, Indonesia, to learn about the biopesticides they use to keep out of pests. They stated that they use a blend of 3-5 trees around their farm to generate biopesticides; this information is consistent with what the author learned from the Baduy Tribes regarding insect management. Finally, the author interviewed one of the civil apparatus in charge of plant pest control at the Banten Provincial Agriculture Department. She stated that the government is concerned with assisting farmers in using biopesticides. She said several trees may be utilized as biopesticides, and neem trees are one of them. The Banten Province Department of Agriculture frequently conducts training to strengthen local farmers' skills to increase productivity by managing pests.

### **CONCLUSION**

The neem tree (*Azadirachta indica*) has been extensively documented in ancient Indian texts, such as the Rigveda and Atharvaveda, as a biopesticide used for pest control in agriculture. Traditional practices in ancient India involved the preparation and application of neem tree extracts, such as neem leaf decoctions and neem oil-based sprays, for pest management. The neem tree held cultural and spiritual significance in ancient Indian society, being associated with deities and religious beliefs. Historical connections between India and Indonesia facilitated the spread of neem tree-based biopesticides to Indonesia, where they were adopted and integrated into traditional agricultural practices. Indonesian farmers embraced the use of neem tree-based biopesticides and recognized their efficacy in pest control, contributing to sustainable agricultural practices.

Overall, this research provides valuable insights into the historical, cultural, and practical aspects of using neem tree as biopesticides in ancient India and its subsequent adoption in



Indonesian agriculture. The findings contribute to the existing knowledge, highlighting the importance of traditional practices, cultural significance, and the potential for sustainable pest management strategies. These findings have implications for agriculture and sustainability, offering opportunities for the development of environmentally friendly pest control methods and the promotion of traditional ecological knowledge in modern agricultural practices.

## REFERENCES

- Acharya, P., Mir, S. A., & Nayak, B. (2017). Competence of Biopesticide and Neem in Agriculture. *International Journal of Environment, Agriculture and Biotechnology*, 2(6), 2958–2964. <https://doi.org/10.22161/ijeab/2.6.23>
- Amit Kumar Tiwari, Indra Jeet Chaudhary, A. K. P. (2019). Indian traditional trees and their scientific relevance. *Journal of Medicinal Plants*, 7(3), 29–32. [https://doi.org/ISSN \(E\): 2320-3862; ISSN \(P\): 2394-0530](https://doi.org/ISSN (E): 2320-3862; ISSN (P): 2394-0530)
- Ascher, K. R. S. (1993). Nonconventional insecticidal effects of pesticides available from the Neem tree, *Azadirachta indica*. *Archives of Insect Biochemistry and Physiology*, 22(3–4), 433–449. <https://doi.org/10.1002/arch.940220311>
- Asogwa, E. U., Ndubuaku, T. C. N., Ugwu, J. A., & Awe, O. O. (2010). Prospects of botanical pesticides from neem, *Azadirachta indica* for routine protection of cocoa farms against the brown cocoa mirid - *Sahlbergella singularis* in Nigeria. *Journal of Medicinal Plants Research*, 4(1), 001–006. <https://doi.org/10.5897/JMPR09.049>
- Bajwa, A. A., & Ahmad, A. (2012). Potential applications of Neem based products as biopesticides. *The Health*, 3(4), 116–120.
- Boadu, K. O., Tulashie, S. K., Anang, M. A., & Kpan, J. D. (2011). Production of natural insecticide from Neem leaves (*Azadirachta indica*). *Asian Journal of Plant Science and Research*, 1(4), 33–38.
- Boeke, S. J., Boersma, M. G., Alink, G. M., Van Loon, J. J. A., Van Huis, A., Dicke, M., & Rietjens, I. M. C. M. (2004). Safety evaluation of neem (*Azadirachta indica*) derived pesticides. *Journal of Ethnopharmacology*, 94(1), 25–41. <https://doi.org/10.1016/j.jep.2004.05.011>
- Brahmachari, G. (2004). Neem - An omnipotent plant: A retrospection. *ChemBioChem*, 5(4), 408–421. <https://doi.org/10.1002/cbic.200300749>
- Calo, A. (2014). Ancient trade between India and Indonesia. *Science Magazine*, 1254.
- Debashri, M., & Tamal, M. (2012). A Review on efficacy of *Azadirachta indica* A. Juss based biopesticides: An Indian perspective. *Research Journal of Recent Sciences*, 1(3), 94–99. [www.isca.in](http://www.isca.in)
- Dimetry, N. Z. (2012). Prospects of botanical pesticides for the future in integrated pest management programme (IPM) with special reference to neem uses in Egypt. *Archives of Phytopathology and Plant Protection*, 45(10), 1138–1161. <https://doi.org/10.1080/03235408.2012.657932>
- Elvira, N. D., & Wuryandari, Y. (2023). Utilization of Neem Leaves as a Biological Pesticide for the Control of Anthracnose Diseases in Dragons ( *Hylocereus* sp .). *Conference*

*Paper, Seminar Nasional Agroteknologi 2022*, 2023(1993), 36–40.  
<https://doi.org/10.11594/nstp.2023.3109>

- Gajalakshmi, S., & Abbasi, S. A. (2004). Neem leaves as a source of fertilizer-cum-pesticide vermicompost. *Bioresource Technology*, 92(3), 291–296.  
<https://doi.org/10.1016/j.biortech.2003.09.012>
- Goktepe, I., Portier, R., & Ahmedna, M. (2004). Ecological Risk Assessment of Neem-Based Pesticides. *Journal of Environmental Science and Health - Part B Pesticides, Food Contaminants, and Agricultural Wastes*, 39(2), 311–320. <https://doi.org/10.1081/PFC-120030244>
- Grisakova, M., Metspalu, L., Jogar, K., Hieesar, K., Kuusik, A., & Poldma, P. (2006). Effects of biopesticide Neem EC on the Large White Butterfly, *Pieris brassicae* L. (Lepidoptera, Pieridae). *Agronomy Research (Tartu)*, 4, 181–186.
- Isman, M. B. (2015). A renaissance for botanical insecticides? *Pest Management Science*, 71(12), 1587–1590. <https://doi.org/10.1002/ps.4088>
- Khater, H. F. (2012). Botanicals review 2012 Pharmacologia. *Pharmacologia*, 3(12), 641–656.
- Koul, O. (2004). Chapter 1 Neem : A Global Perspective. In *Neem: Today and in the New Millennium* (pp. 1–19).
- Kumar, V. S., & Navaratnam, V. (2013). Neem (*Azadirachta indica*): Prehistory to contemporary medicinal uses to humankind. *Asian Pacific Journal of Tropical Biomedicine*, 3(7), 505–514. [https://doi.org/10.1016/S2221-1691\(13\)60105-7](https://doi.org/10.1016/S2221-1691(13)60105-7)
- Lokanadhan, S., Muthukrishnan, P., & Jeyaraman, S. (2012). Neem products and their agricultural applications. *Journal of Biopesticides*, 5(SUPPL.), 72–76.
- Manan, A. (2021). *Metode Penelitian Etnografi* (C. I. Salasiyah (ed.)). AcehPo Publishing.
- Mohammed, A. L., & Idriss, M. (2023). Effect of Moringa (*Moringa Oleifera*) Leaf Powder, Neem (*Azadirachta Indica*) Leaf Powder, and Camphor on Weevil (*Callosobruchus Maculatus* F.) in Stored Cowpea (*Vigna Unguiculata* (L.) Walp) Seeds. *Journal of Applied Life Sciences and Environment*, 55(3 (191)), 257–269. <https://doi.org/10.46909/alse-552062>
- Morgan, E. D. (2006). The Place of Neem among Modern Natural Pesticides. *Neem: Today and in the New Millennium*, 21–32. [https://doi.org/10.1007/1-4020-2596-3\\_2](https://doi.org/10.1007/1-4020-2596-3_2)
- Pandey, G., Verma, K., & Singh, M. (2014). Evaluation of phytochemical, antibacterial and free radical scavenging properties of *Azadirachta indica* (neem) leaves. *International Journal of Pharmacy and Pharmaceutical Sciences*, 6(2), 444–447.
- Pullaiah, T., Krishnamurthy, K. V., Bir, B., Adams, S. J., Sikarwar, R. L. S., Ray, S., Rahaman, C. H., Mandal, S. K., Ved, D. K., Begum, S. N., Kumar, K. R., Wagh, V. V., Ramaiah, M., Rao, J. K., Suneetha, J., Manjula, R. R., Reddi, T. V. V. S., Kaur, B., Murthy, K. S. R., ... Srinivas, A. (2018). *Ethnobotany of India : Volume 5 - The Indo-Gangetic Region and Central India* (T. Pullaiah, K. V. Krishnamurthy, & B. Bir (eds.)). CRC Press.
- Rosenkranz, H. S., & Klopman, G. (1995). An Examination of The Potential “Genotoxic” Carcinogenicity of A Biopesticide Derived From The Neem Tree. *Environmental and Molecular Mutagenesis*, 26(3), 255–260. <https://doi.org/10.1002/em.2850260311>

- Roychoudhury, R. (2016). Neem Products. *Ecofriendly Pest Management for Food Security*, 563–611. <https://doi.org/10.1016/B978-0-12-803265-7.00019-1>
- Saenong, M. S. (2017). Tumbuhan Indonesia Potensial sebagai Insektisida Nabati untuk Mengendalikan Hama Kumbang Bubuk Jagung (*Sitophilus* spp.). *Jurnal Penelitian Dan Pengembangan Pertanian*, 35(3), 131. <https://doi.org/10.21082/jp3.v35n3.2016.p131-142>
- Sarumaha, A. (2022). *Efikasi Ekstrak Buah Maja, Daun Mimba, dan Daun Pepaya Sebagai Mollussida Nabati Dalam Pengendalian Hama Siput Setengah Telanjang (Parmarion martensi) Pada Tanaman Kubis (Brassica oleracea var. capitata\_*. Universitas Medan Area.
- Schmutterer, H. (1990). Properties and potential of natural pesticides from the neem tree, *Azadirachta indica*. *Annual Review of Entomology*, 35(1), 271–297. <https://doi.org/10.1146/annurev.en.35.010190.001415>
- Sugiyono. (2018). *Metode penelitian kuantitatif, kualitatif dan kombinasi (mixed methods)*.
- Sukarsno. (2003). *Mengenal Lebih Dekat MIMBA Tanaman Obat Multifungsi* (T. Lentera (ed.)). PT. AgroMedia Pustaka.
- Taylor, P., & Gahukar, R. T. (2010). International Journal of Pest Management Use of neem products / pesticides in cotton pest management. *International Journal of Pest Management, October 2011*, 37–41.
- Uli, A., Siti Harnina, B., & Dewi, T. . (2014). Efek Antibakteri Ekstrak Daun Mimba (*Azadirachta indica* A. Juss) terhadap Bakteri *Vibrio alginolyticus* Secara In Vitro. *Biosaintifika: Journal of Biology & Biology Education*, 6(1), 67–75.
- Vithalkar, A., Kaiwartya, K., & Patel, Y. K. (2023). The Green Gold-Neem : A Review. *TIJER - International Research Journal*, 10(1), 62–77.
- Weathersbee, A. A., & McKenzie, C. L. (2005). Effect of a neem biopesticide on repellency, mortality, oviposition, and development of *Diaphorina citri* (Homoptera: Psyllidae). *Florida Entomologist*, 88(4), 401–407. [https://doi.org/10.1653/0015-4040\(2005\)88\[401:EOANBO\]2.0.CO;2](https://doi.org/10.1653/0015-4040(2005)88[401:EOANBO]2.0.CO;2)