

Original Research Article

A Study on Sustainable Neem Seed Collection and Utilization Practices in Selected Cluster of Tamil Nadu

ABSTRACT

The neem tree (*Azadirachta indica*), frequently called a "miracle tree," possesses significant commercial and medicinal value. It is extensively grown in India, particularly in states such as Uttar Pradesh, Tamil Nadu, and Karnataka. Various components of the tree, including its seeds, oil, and leaves, are essential for the production of pesticides, medicinal products, and inputs for organic agriculture. Despite its potential, the neem industry in India remains largely untapped, with only a minor portion of its capabilities being utilized. The sustainable harvesting of neem seeds is vital for the health of neem trees and the assurance of long-term yields, yet it encounters numerous challenges. This study aims to explore the socio-economic conditions of neem seed collectors, assess their challenges, and investigate their collection practices. This research was conducted in four villages within the Sivagangai district of Tamil Nadu. Data was gathered through personal interviews with 160 participants, employing percentage analysis and Garret Ranking methods. The findings revealed that most neem seed collectors were middle-aged (46-60 years) and had limited formal education. The primary occupation among these collectors was farming, especially in Devakkottai and Thiruppathur, while Singampunari had a notable number of business owners. A majority of collectors sourced seeds in proximity to their residences, with a significant portion possessing 4-6 years of experience. Major challenges identified included the labour-intensive nature of the collection process, the considerable distances travelled, and health-related concerns. The study highlights the necessity for improved infrastructure, training, and support to enhance the neem seed collection process, thereby uplifting the livelihoods of rural communities and fostering environmental sustainability.

Keywords: Neem, Neem seed, Collection, Rural people, Socio-economic factors, Constraints

INTRODUCTION

Comment [M1]: Italics

The neem tree, scientifically designated as *Azadirachta indica* and commonly known as the miracle tree of India, is making a shift from research environments to commercial applications. A variety of companies in the United States and Australia are engaged in the development of insecticides derived from neem. The considerable export potential of neem is attracting the attention of producers who have previously concentrated solely on domestic neem-based products. At present, more than 30 distinct neem-based pesticides are being produced within the country. For example, neem oil can be administered twice daily to relieve discomfort and eradicate bacteria, while azadirachtin, in concentrations ranging from 1 to 50 ppm, can be employed to control Lepidoptera pests [1].

Comment [M2]: Italyze

The neem tree, or *Azadirachta indica* in scientific terms, is an evergreen species native to the tropical areas of India. Frequently called the village pharmacy, it is typically located along roadsides and in communal spaces within villages. This tree demonstrates a remarkable ability to fix carbon dioxide, with the potential to absorb more than 14 micromoles of carbon dioxide per square meter per second [2]. Neem seeds possess significant economic value due to their various commercial uses. The quality of these seeds is essential in influencing their market price. From a single tonne of neem seeds, one can extract 1.50 kg of azadirachtin, 200 kg of neem oil, and 780 kg of neem cake [3]. Clinical research has shown that neem is beneficial in preventing a range of disorders. The active constituents found in neem have been identified as having a chemo preventive effect on various tumor types by modulating several cellular signaling pathways [4]. The leaves of the Neem tree appear to generate a distinctive group of glycoproteins known as neem leaf glycoprotein (NLGP). When tested in mammalian subjects, this glycoprotein demonstrated immune-modulatory properties, potentially aiding in the inhibition of tumor progression by influencing both local and systemic immune responses [5]. Various health issues have been demonstrated to benefit from neem treatment. Neem leaves are available as tea or in capsule form. Moreover, neem oil can be used topically or consumed by adding a few drops to an empty capsule. In addition, it is beneficial for improving soil fertility [6]. The health benefits associated with various compounds and extracts derived from Neem, as well as the mechanisms and pathways through which these constituents operate, warrant recognition. Nevertheless, it is crucial to exercise caution, as extracts produced in unsanitary and unregulated conditions may result in health issues, given that certain compounds can adversely affect the liver and kidneys [7]. In areas like India, Pakistan, and other developing nations in the East, the integration of complementary medicine with allopathic methods is widespread. Numerous healing traditions, with

Comment [M3]: Also mention the quantity required for management of lepidopteran pests/ha.

Comment [M4]: Italyze

Ayurveda being especially significant, focus on concepts of balance, energy, and spiritual healing. These traditions prominently feature a variety of therapies that employ an extensive selection of herbs and plants, such as Turmeric, Amla, Tulsi, Guggul, and Neem [8]. India holds a favorable position in the neem industry, marked by the availability of high-quality oil and seeds, as well as an abundant supply of raw materials. However, the sector has not progressed as expected. Challenges in exporting stem from regulatory restrictions in multiple countries, indicating that prioritizing the domestic market could prove more advantageous. Ongoing difficulties in exporting and marketing are compounded by the presence of pollutants and contaminants, including lead and aflatoxin, in the oil [9]. The sustainable harvesting of neem seeds is crucial for maintaining ecological equilibrium while also leveraging the economic advantages of *Azadirachta indica*. This tree, native to the Indian subcontinent, has gained global recognition for its diverse applications in agriculture, medicine, and industry [10]. Sustainable harvesting practices emphasize the manual gathering of ripe fruits from the ground or the utilization of long-handled tools to reach lower branches. Such approaches minimize damage to the trees and support the ongoing health of neem populations [11]. Sustainable harvesting practices emphasize the manual gathering of ripe fruits from the ground or the utilization of long-handled tools to reach lower branches. Such approaches minimize damage to the trees and support the ongoing health of neem populations [12]. The engagement of the community is essential for the efficient and sustainable gathering of neem seeds, which can provide supplementary income while also contributing to environmental preservation. Educating local residents about proper harvesting techniques and the long-term benefits of sustainable practices can lead to enhanced conservation outcomes. Furthermore, establishing fair trade partnerships and providing economic incentives for sustainable collection can motivate communities to adopt and maintain these practices [13]. Adopting sustainable practices for neem seed collection guarantees a consistent supply of high-quality seeds for diverse uses, while also protecting the ecological health of neem forests. This strategy not only fosters environmental preservation but also enhances the economic stability of rural communities that rely on neem resources [15]. In this context the study aims i) to assess the involvement of rural households in neem seed collection and identify the challenges they face during collection and sale. ii) to investigate the socio-economic factors influencing the participation of rural households in neem seed collection, focusing on the livelihoods of neem seed collectors.

Comment [M5]: Italyze

MATERIALS AND METHODS

To achieve the study's objective, primary data was collected through personal interviews following an established interview the schedule. The questionnaire was carefully designed and distributed to consumers in Sivagangai District's specified regions. The entire sample size was 160 people, and primary data collection took place between May and June 2024. Four villages were chosen from Sivagangai district's 12 blocks due to the high number of neem seed collectors (Singampunari, Thiruppathur, Devakottai, and Karaikudi). The members were chosen only from rural areas. Based on statistical assessment, 160 sample respondents (40 from each of four blocks)

Percentage Analysis

Percentage analysis is one of the traditional economic instruments used commonly in primary data interpretation. The number of responses by the respondents to a specific question is the proportion of the total respondents chosen for the research

$$\text{Percentage} = \frac{\text{Number of respondents by the respondents to the specific question}}{\text{Total number of respondents}} * 100$$

Garret Ranking:

Garret Ranking is a technique used to rank and prioritize various factors or constraints based on respondents' preferences. This method is use to rank the key drivers and barriers influencing the adoption of blended oils among the consumers. Ranks were converted into per cent position by using the formula,

$$\text{Percent position} = 100 \times (R_{ij} - 0.5) / N_j * 100$$

Where,

R_{ij} = Rank given to the i^{th} attribute by the j^{th} individual.

N_j = number of attributes ranked by the j^{th} individual.

By referring to Garret's table, the per cent position estimated was converted into scores.

RESULT AND DISCUSSION

Age of the Neem Seed Collectors

The age of the neem seed collectors was significant in neem seed collection as it influenced capability experience and economic needs. The details related to the age of the sample respondents are furnished in Table 1.

Comment [M6]: were

Table 1 Age of the Neem Seed Collectors

(n=160)

S. No	Age (Years)	Number of Neem seed Collectors			
		Singampunari (40)	Thiruppathur (40)	Devakkottai (40)	Karaikudi (40)
1.	Under 18	1 (2.50)	3 (7.50)	1 (2.50)	3 (7.50)
2.	18 – 30	5 (12.5)	9 (22.50)	6 (15.00)	10 (25.00)
3.	31 – 45	3 (7.50)	13 (32.50)	11 (27.50)	9 (22.50)
4.	46 - 60	18 (45.00)	10 (25.00)	12 (30.00)	14 (35.00)
5.	Above 60	13 (32.50)	5 (12.50)	10 (25.00)	4 (10.00)
	Total	40 (100.00)	40 (100.00)	40 (100.00)	40 (100.00)

It could be inferred from Table 1 that the majority of the neem seed collectors in Singampunari (45 percent) and Karaikudi (35 per cent) belonged to the age group of 46-60 years, about 32.50 per cent of neem seed collectors belonged to 31-45 years of age followed by 25 per cent of 46-60 years in Thiruppathur. Most of the neem seed collectors in Devakkottai belonged to those above 60 years of age 10 per cent which is comparatively high with respect to other locations. Further concluded that Thiruppathur has a higher percentage of collectors in the age range of 31 to 45, whereas the greater number of collectors in Singampunari and Karaikudi are between 46 and 60 years old. In Devakkottai, there are a significant number of collectors aged 46 to 60, as well as those over 60 years old.

Education level of the neem seed collectors

The education level of neem seed collectors plays an important role in their work, affecting their skills, experience, and job opportunities. Table 2 provides information about the education levels of the respondents.

Table 2 Education level of the neem seed collectors

(n=160)

S. No	Category	Number of Neem seed Collectors			
		Singampunari (40)	Thiruppathur (40)	Devakkottai (40)	Karaikudi (40)
1.	No formal education	18 (45.00)	13 (32.50)	15 (37.50)	16 (40.00)
2.	Primary education	11 (27.50)	3 (7.50)	5 (12.50)	10 (25.00)
3.	Secondary education	8 (20.00)	9 (22.50)	11 (27.50)	9 (22.50)
4.	Higher secondary education	2 (5.00)	10 (25.00)	5 (12.50)	4 (10.00)
5.	Higher education	1 (2.50)	5 (12.50)	4 (10.00)	1 (2.50)
	Total	40 (100.00)	40 (100.00)	40 (100.00)	40 (100.00)

It could be inferred from Table 2, that most neem seed collectors in Singampunari (45.00 per cent) and Karaikudi (40.00 per cent) had no formal education. In Thiruppathur, 32.50 per cent also lacked formal education, with 25.00 per cent had completed higher secondary education. Devakkottai had a more balanced distribution, where 37.50 per cent had no formal education and 27.50 per cent had secondary education. Higher education was rare in all areas, whereas the thiruppathur area had the highest percentage 12.50 per cent. Primary education was most common in Singampunari (27.50

per cent) and Karaikudi (35.00 per cent), while secondary education was most frequent in Devakkottai (27.50 per cent). Further concluded that a considerable proportion of neem seed collectors in each of the four locations (Devakkottai, Karaikudi, Thiruppathur, and Singampunari) lack a formal education, with percentages ranging from 32.50 per cent to 45 per cent. Neem seed Collectors have a lower proportion of primary or secondary education, and even fewer have finished further school or higher education. This indicates that the majority of people who harvest neem seeds in these areas are not very well educated.

Occupation level of neem seed collectors

The job status of neem seed collectors is important because it affects their skills, experience, and financial needs. Table 3 provides information about the job status of the respondents.

Table 3 Occupation level of neem seed collectors

(n=160)

S. No	Occupation status	Number of Neem seed Collectors			
		Singampunari (40)	Thiruppathur (40)	Devakkottai (40)	Karaikudi (40)
1.	Farming	10 (25.00)	23 (57.50)	25 (62.50)	23 (57.50)
2.	Business	16 (40.00)	9 (22.50)	8 (20.00)	9 (22.50)
3.	Labourer	13 (32.50)	3 (7.50)	6 (15.00)	6 (15.00)
4.	Student	1 (2.50)	5 (12.50)	1 (2.50)	2 (5.00)
	Total	40 (100.00)	40 (100.00)	40 (100.00)	40 (100.00)

It could be inferred from Table 3 that most neem seed collectors in Thiruppathur and Karaikudi (57.50 per cent) and Devakkottai (62.50 per cent) worked in farming. In Singampunari, the

largest group (40.00 per cent) was in business, followed by labourers at 32.50 per cent. Karaikudi had a more balanced mix, with 57.50 per cent in farming and 22.50 per cent in business. The student group was the smallest in all areas, with only 2.50 per cent in Singampunari and Devakkottai. Thiruppathur had the highest percentage of students at 12.50 Per cent. Laborers were most common in Singampunari (32.50 per cent) and least common in Thiruppathur (7.50 per cent). Further concluded that farming is the most common occupation among neem seed collectors in Thiruppathur and Devakkottai, with a considerable number also working in Karaikudi. Compared to other regions, Singampunari has fewer collectors in farming, making business the predominant activity. In all areas, the percentage of collectors is lower for laborers and students.

Place of Neem Seed Collection of Neem Seed Collectors

Table 4 shows where neem seed collectors gather seeds. The distance of location was important because it affects how easy it is to access resources. The information about where the sample respondents collected seeds is presented in Table 4.

Table 4 Place of Neem Seed Collection of Neem Seed Collectors

(n=160)

S. No	Place of neem seed collection	Number of Neem seed Collectors			
		Singampunari (40)	Thiruppathur (40)	Devakkottai (40)	Karaikudi (40)
1.	Around home	24 (60.00)	26 (65.00)	27 (67.50)	23 (57.50)
	Local village	14 (35.00)	12 (30.00)	7 (17.50)	10 (25.00)
3.	Nearby village	2 (5.00)	2 (5.00)	6 (15.00)	7 (17.50)
	Total	40 (100.00)	40 (100.00)	40 (100.00)	40 (100.00)

It could be inferred from Table 4, that most neem seed collectors in all areas collected seeds near their homes: Singampunari (60.00 per cent), Thiruppathur (65.00 per cent), Devakkottai (67.50 per cent), and Karaikudi (57.50 per cent). The second most common place for collection was the local village, with Singampunari, followed by Thiruppathur at 30.00 per cent. Karaikudi had the highest percentage of collectors gathering from nearby villages at 17.50 per cent, which was relatively high compared to the other areas. Further concluded that most Neem seed collectors in Singampunari, Thiruppathur, Devakkottai, and Karaikudi harvest seeds near their homes, with percentages ranging from 60 per cent to 67.50 per cent. A smaller number collects neem seed within their own neighbourhoods, whereas only a few travel to nearby villages to collect neem seed. Neem seed Collectors from Devakkottai and Karaikudi are least likely to collect seeds from villages nearby.

Experience of Neem Seed Collection of Neem Seed Collectors

The experience of neem seed collectors plays a crucial role in how they gather seeds, affecting their skills, efficiency, and knowledge of the best methods. Table 5 provides details about the experience of the surveyed collectors.

Table 5 Experience of Neem Seed Collection of Neem Seed Collectors

(n=160)

S. No	Experience in neem seed collection	Number of Neem seed Collectors			
		Singampunari (40)	Thiruppathur (40)	Devakkottai (40)	Karaikudi (40)
1.	Less than 1 year	1 (2.50)	7 (17.50)	7 (17.50)	13 (32.50)
	1-3 years	2 (5.00)	2 (5.00)	6 (15.00)	1 (2.50)
3.	4-6 years	28 (70.00)	27 (67.50)	22 (55.00)	18 (45.00)

4.	More than 6 years	9 (22.50)	4 (10.00)	5 (12.50)	8 (20.00)
	Total	40 (100.00)	40 (100.00)	40 (100.00)	40 (100.00)

It could be inferred from Table 5, that most neem seed collectors across all areas have 4-6 years of experience: Singampunari (70.00 per cent), Thiruppathur (67.50 per cent), Devakkottai (55.00 Per cent), and Karaikudi (45.00 per cent). Singampunari had the highest number of collectors with over 6 years of experience at 22.50 per cent. Karaikudi had the largest share of collectors with less than 1 year of experience at 32.50 per cent, which is notably higher than in other areas. Devakkottai had a more balanced range of experience levels among its collectors. Further concluded that the majority of Neem seed collectors in all four locations Singampunari, Thiruppathur, Devakkottai, and Karaikudi have 4-6 years of experience, with percentages ranging from 45 per cent to 70 per cent. A less percentage has more than 6 years of experience, whereas the least experienced (less than 1 year) account for a small shares, particularly in Singampunari. Karaikudi, Thiruppathur and Devakottai have the largest percentage of neem seed collectors with less than one year of experience.

Constraints faced during the collection of neem seed

Table 6 Constraints faced during the collection of neem seed

Constraints	Mean score	Rank
More time consuming	64.92	I
Long distance	60.02	II
Poor health- unable to walk	53.06	III
Less remunerative	51.28	IV
Less productive	47.52	V
Less dignified	37.96	VI
Lack of source	35.22	VII

It could be inferred from the Table 6 that the major constraints faced by the neem seed collectors were "More time consuming" (64.92) Gathering seeds from several trees, especially when they are spread out over a vast region, takes up an important part of the day, leaving little spare time for other activities or work. the second constraint was "Long distance" (60.02) Neem trees are situated far away from the collectors' houses or villages. This large distance involves extensive travel, frequently by foot, which can be demanding and time-consuming, complicating the collection process. The third constraint was "Poor health- unable to walk" (53.06) neem seed collectors with health difficulties, particularly those that impact travel, encounter major obstacles. Walking long distances to collect Neem seeds becomes more challenging, restricting their ability to participate in this activity and might decrease their income. the fourth constraint was "Less remunerative" (51.28) Despite the effort required, collecting Neem seeds is rarely financially rewarding. Selling seeds generates some revenue, making it less attractive than other forms of labour or agricultural activity. the fifth constraint was "Less productive" (47.52) Neem seed collecting may give low yields, particularly if trees are low or the harvest is poor. This low productivity means that even after hours of collection, the amount of seeds obtained may not be worth the labour, resulting in limited returns. the sixth constraint was "Less dignified" (37.96) Neem seed collection may be perceived as a less prestigious or dignified occupation than other types of job. This view can influence people's willingness to participate in the activity since they may believe it is undervalued or negatively viewed by society. and the seventh constraint was "Lack of source" (35.22) The availability of Neem trees is an important consideration in seed collection. In locations where Neem trees are uncommon or have been exhausted, collectors suffer an abundance of source material, making it difficult or impossible to gather enough seeds to justify the effort. This shortage may also increase competition among collectors, resulting in lower individual yields. The time-consuming nature of the activity or product use appears to be the primary concern for the respondents. Travel requirements also pose a significant challenge, suggesting accessibility issues. Health limitations, particularly mobility constraints, rank third, indicating the importance of physical well-being for participation. Economic factors such as remuneration and productivity are mid-ranked concerns, while dignity and sourcing issues are relatively less significant but still notable obstacles.

Comment [M7]: T

Comment [M8]: T

Comment [M9]: Remove it

Comment [M10]: The

Comment [M11]: Remove it

Comment [M12]: were

Comment [M13]: were

Constraints faced during selling neem seeds in the market

Table 7 Constraints faced during selling neem seeds in the market

Constraints	Mean score	Rank
Poor price	73.50	I
Lack of awareness about the prices in other markets	55.71	II
Lack of awareness about quality	53.10	III
Lack of transport facilities	42.91	IV
Malpractice in weighing	40.84	V
Storage problem	33.92	VI

It could be inferred from Table 7 that the major constraints faced during selling neem seeds in the market were "Poor price" (73.50) Neem seed collectors frequently face low prices for their produce, making it difficult to cover the costs of collection and processing. This economic difficulty could discourage collectors and reduce their income. In last season the price of neem seed is Rs.150/kg but in some markets the neem seed was sold for low value than the actual market value, then the second constraint was "Lack of awareness about the prices in other markets" (55.71). Many collectors are unaware of the rates that Neem seeds earn in different marketplaces. This lack of information prevents businesses from negotiating better prices or seeking out more profitable markets, potentially resulting in decreased profits. the third constraint was "Lack of awareness about quality" (53.10) Neem seed purity, moisture content, germination rate, seed size, and oil content were all important factors in determining their marketability and economic value. Neem seed Collectors who were unaware of these requirements frequently failed to correctly assess and sort their seeds, results in lower prices and lost competitiveness in the market, followed by "Lack of transport facilities" (42.91) Insufficient transportation facilities might make it difficult for collectors to move Neem seeds from collection areas to markets. This constraint might lead to delays, increased expenses, and potentially spoiling of seeds, "Malpractice in weighing" (40.84). Malpractice during the weighing of Neem seeds, such as dishonest acts by middlemen or buyers, might result in collectors gets less money than they deserved for their seeds. This issue reduces trust in the transaction process, and "Storage problem" (33.92). Many collectors lack access to proper storage facilities, causing them to keep seeds in poor

Comment [M14]: The

circumstances, such as homes or temporary shelters, where they become susceptible to environmental impacts. The poor price of neem seeds appears to be the primary concern for the sellers. Lack of awareness about prices in other markets and about quality are significant challenges, suggesting information asymmetry issues. Transportation difficulties rank fourth, indicating logistical problems. Malpractice in weighing is a mid-ranked concern, pointing to potential unfair practices in the market. Storage issues, while ranked last, are still a notable obstacle.

Comment [M15]: Remove the sentences already mentioned above

Conclusion

The research of neem seed collectors in Singampunari, Thiruppathur, Devakkottai, and Karaikudi provides valuable information on their backgrounds and challenges. The majority of collectors are between the ages of 46 and 60, indicating that they have much expertise but may also have physical limitations. Many of them have less education, which can have an impact on their ability to operate effectively. The majority of collectors are involved in farming, while Singampunari has more business activity. They usually collect seeds near their houses, which is convenient but limits access to further resources. Most collectors have 4-6 years of experience, however there are plenty of newcomers. The main problems include the time required to collect seeds, the need to travel long distances, the poor income, and the lack of market knowledge. These difficulties highlight the need for improved market information, transportation, and education. Addressing these issues can assist improve the financial status of neem seed collectors and promote sustainable practices.

Comment [M16]: Add Moreover, over the past two years, neem trees in most southern states have been affected by dieback disease, leading to a significant reduction or complete unavailability of neem seeds.

REFERENCES

1. Rahal, A., Kumar, D., & Malik, J. K. (2019). Neem extract. *Nutraceuticals in Veterinary Medicine*, 37-50.
2. Bijalwan Arvind, Manmohan JR Dobriyal, Tarun Kumar Thakur, Pooja Verma, Shalini Singh. *Biosciences and Plant Biology. Int. J. Curr. Res. Biosci. Plant Biol.* 2017; 4(1):113-118
3. Lokanadhan, S., Muthukrishnan, P., & Jeyaraman, S. (2012). Neem products and their agricultural applications. *Journal of Biopesticides*, 5, 72.

4. Alzohairy, M. A. (2016). Therapeutics role of Azadirachta indica (Neem) and their active constituents in diseases prevention and treatment. *Evidence-Based Complementary and Alternative Medicine*, 2016(1), 7382506.
5. Kundu, P. I. J. U. S. H., et al. "Chemical investigation of neem leaf glycoprotein used as immunoprophylactic agents for tumor growth restriction." *Int. J. Pharm. Pharm. Sci* 7 (2015): 195-199.
6. Roshan, A., & Verma, N. K. (2015). A brief study on neem (Azadirachta indica A.) and its application—A review. *Research Journal of Phytomedicine*, 1(1), 01-03.
7. Islas, J. F., Acosta, E., Zuca, G., Delgado-Gallegos, J. L., Moreno-Treviño, M. G., Escalante, B., & Moreno-Cuevas, J. E. (2020). An overview of Neem (Azadirachta indica) and its potential impact on health. *Journal of Functional Foods*, 74, 104171.
8. Anjali Tiwari, A. T., Ankit Pandey, A. P., & Verma, O. P. (2016). Phytochemical screening of Ocimum sanctum (Tulsi), Azadirachta indica (Neem) and Phyllanthus emblica (Amla).
9. Roychoudhury, R. (2016). Neem products. In *Ecofriendly pest management for food security* (pp. 545-562). Academic Press.
10. Lokanadhan, S., Muthukrishnan, P., & Jeyaraman, S. (2012). Neem products and their agricultural applications. *Journal of Biopesticides*, 5, 72-76.
11. Orwa, C. (2009). Agroforestry Database: a tree reference and selection guide, version 4.0. [http://www. World agroforestry. org/sites/treedbs/treedatabases. asp](http://www.worldagroforestry.org/sites/treedbs/treedatabases.asp).
12. Puri, H. S. (1999). *Neem: the divine tree Azadirachta indica*. CRC Press.
13. Kumar, J., & Parmar, B. S. (1996). Physicochemical and chemical variation in neem oils and some bioactivity leads against Spodoptera litura F. *Journal of agricultural and food chemistry*, 44(8), 2137-2143.
14. Schmutterer, H. (1990). Properties and potential of natural pesticides from the neem tree, Azadirachta indica. *Annual review of entomology*, 35(1), 271-297.