PLANT SCIENCE TODAY
ISSN 2348-1900 (online)
Vol 12(sp1): 01–06
https://doi.org/10.14719/pst.5747

HORIZON
e-Publishing Group
HePG

RESEARCH ARTICLE

A study on sustainable neem seed collection and utilization practices in selected cluster of Tamil Nadu

Syed Abudahir B[1], Indumathi VM[1*], Moghanalavanya S[1], Kalpana M[2] & Suganya S[3]

[1]Department of Agricultural and Rural Management, Tamil Nadu Agricultural University, Coimbatore 641 003, Tamil Nadu, India

[2]Agricultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore 641 003, Tamil Nadu, India

[3]Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University, Coimbatore 641 003, Tamil Nadu, India

*Email: induarm@tnau.ac.in

OPEN ACCESS

ARTICLE HISTORY
Received: 12 October 2024
Accepted: 24 October 2024
Available online
Version 1.0 : 27 January 2025

Check for updates

Additional information
Peer review: Publisher thanks Sectional Editor and the other anonymous reviewers for their contribution to the peer review of this work.

Reprints & permissions information is available at https://horizonepublishing.com/journals/index.php/PST/open_access_policy

Publisher's Note: Horizon e-Publishing Group remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Indexing: Plant Science Today, published by Horizon e-Publishing Group, is covered by Scopus, Web of Science, BIOSIS Previews, Clarivate Analytics, NAAS, UGC Care, etc
See https://horizonepublishing.com/journals/index.php/PST/indexing_abstracting

CITE THIS ARTICLE
Abudahir SB, Indumathi VM, Moghanalavanya S, Kalpana M, Suganya S. A study on sustainable neem seed collection and utilization practices in selected cluster of Tamil Nadu. Plant Science Today. 2025; 12 (sp1):01-06.
https:/doi.org/10.14719/pst.5747

Abstract

Neem (*Azadirachta indica),* often referred to as the "miracle tree" of India, has attracted considerable interest due to its commercial and therapeutic benefits, evolving from local utilization to global markets, especially in the United States and Australia. Currently, more than 30 neem-based pesticides are produced domestically, highlighting neem's extensive potential across various applications, including neem oil and azadirachtin for pest control. This tree is vital to India's ecosystem, particularly in regions such as Uttar Pradesh, Tamil Nadu and Karnataka, where it yields an average of 35 kg of fruit per tree annually. The seeds of the neem tree are economically significant for their oil and medicinal attributes, yielding essential components like azadirachtin and neem cake. This research investigates sustainable practices for neem seed collection, highlighting the importance of appropriate timing, harvesting techniques and training for rural communities to promote ecological sustainability and economic viability. Implementing sustainable methods not only protects the health of neem trees but also establishes reliable income streams for rural residents. The study gathered primary data through interviews with 160 individuals in a designated district of Tamil Nadu, India. Factor analysis was utilized to identify the socio-economic and market factors that affect neem seed collection.

Keywords

collection; neem; neem seed; rural people; socio economic

Introduction

The neem tree, known scientifically as *Azadirachta indica* and often referred to as the "miracle tree" of India, is transitioning from research laboratories to commercial markets. Numerous companies in the United States and Australia are actively developing insecticides derived from neem. The significant export potential of neem is drawing interest from producers who previously focused exclusively on domestic neem-based products. Currently, over 30 different neem-based pesticides are being manufactured in the country. Neem has garnered global attention for its eco-friendly nature and effectiveness as a natural pesticide. Unlike synthetic chemicals, neem-based products are biodegradable, safe for humans and animals and have minimal impact on beneficial insects and the environment. Its active compound, azadirachtin, disrupts pest growth and reproduction without leading to resistance-a frequent drawback of synthetic pesticides. Furthermore, neem enhances soil health and finds extensive use across agriculture, medicine and cosmetics, making it a versatile and sustainable alternative to conventional pesticides. For instance, neem oil can be applied twice daily to alleviate discomfort and eliminate bacteria, while

azadirachtin, at concentrations ranging from 1 to 50 ppm, can be utilized to manage Lepidoptera pests (1).

The neem tree, scientifically known as *Azadirachta indica*, is an evergreen species indigenous to tropical regions of India. Often referred to as the "village pharmacy", neem is commonly found along roadsides and in communal areas of villages. This tree exhibits a notably high capacity for carbon dioxide fixation, capable of absorbing over 14 micromoles of carbon dioxide per square meter per second (2). Neem seeds are economically important due to their diverse commercial uses. The quality of the seeds plays a crucial role in determining their market value. From one tonne of neem seeds, it is possible to extract 1.50 kg of azadirachtin, 200 kg of neem oil and 780 kg of neem cake (3). Clinical studies have demonstrated that neem is effective in the prevention of various disorders. The active compounds present in neem have been found to exert a chemo preventive effect on multiple types of tumours by influencing several cellular signalling pathways (4). The neem leaves seem to produce a unique set of glycoproteins called neem leaf glycoprotein (NLGP). When evaluated in mammalian subjects, this glycoprotein exhibited immune-modulatory effects, which may help to restrict tumour development by affecting both local and systemic immune responses (5). Neem (*Azadirachta indica*) is recognized for its therapeutic potential across various health conditions, attributed to its bioactive compounds that exhibit antimicrobial, anti-inflammatory, antioxidant and anticancer properties. It effectively treats skin disorders such as acne, eczema and psoriasis by combating infections and reducing inflammation. Neem extracts have shown anticancer effects, suppressing the growth of tumors in breast, skin and stomach cancers by inducing apoptosis and modifying tumor environments. Furthermore, neem supports oral health by preventing gum disease and cavities, assists in managing diabetes by enhancing insulin sensitivity and fights bacterial, fungal and drug-resistant infections. These versatile benefits underline neem's significance as a natural remedy. Neem leaves can be found in the form of tea or capsules. Additionally, neem oil can be applied topically or ingested by placing several drops in an empty capsule. Furthermore, it is advantageous for enhancing soil fertility (6). The therapeutic benefits of various compounds and extracts derived from neem, along with the mechanisms and pathways through which these neem constituents exert their effects, should be acknowledged. However, it is important to caution Unsanitary manufacturing practices in neem-based product production raise significant concerns, particularly in regions with limited regulatory oversight. For example, in parts of Africa and South Asia, neem oil extraction often relies on untreated water, introducing harmful contaminants that compromise the product's safety. Poor storage facilities in humid climates, such as those in certain Indian regions, lead to fungal contamination of neem seeds, reducing the purity and efficacy of neem oil. Additionally, counterfeit products are prevalent in markets like India, where synthetic additives or diluted formulations are sold under the guise of authentic neem products, posing risks to consumer health and undermining trust. These challenges underscore the critical need for stringent regulations and robust quality control to ensure the safety and effectiveness of neem-based products. At the same time, neem is renowned for its ability to address a range of health issues due to its antimicrobial, anti-inflammatory and antioxidant properties. It is particularly effective in managing skin conditions such as acne, eczema and psoriasis, as well as fungal infections like athlete's foot. Neem also promotes oral health by preventing gum disease, cavities and plaque buildup. In diabetes management, neem leaf extracts help regulate blood sugar levels and improve insulin sensitivity. Its anti-inflammatory properties provide relief for arthritis symptoms, while its antimicrobial effects support digestive health by addressing ulcers and parasitic infections. Neem also enhances immune function and has shown promise in cancer prevention by inducing apoptosis and inhibiting tumour growth. These applications highlight neem's versatility as a valuable natural remedy (7).

In regions such as India, Pakistan and other developing countries in the East, the practice of complementary medicine alongside allopathic approaches is prevalent. Various healing traditions, including Ayurveda are particularly prominent, as they emphasize balance, energy and spiritual healing processes. These traditions notably incorporate a range of therapies that utilize a diverse array of herbs and plants, including turmeric, amla, tulsi, guggul and neem (8).

Despite India's advantageous position in the neem industry, characterized by high-quality oil and seeds along with a plentiful supply of raw materials, the sector has not developed as anticipated. Export challenges arise from regulatory constraints in various countries, suggesting that focusing on the domestic market may be more beneficial. Persistent issues in exporting and marketing include the presence of pollutants and contaminants such as lead and aflatoxin in the oil (9).

The growing demand for neem-based products has led to apprehensions regarding the sustainability of seed collection methods. Conventional practices for collecting neem seeds frequently include detrimental techniques such as cutting branches or shaking trees, which can harm the trees and diminish future production (10). Sustainable harvesting techniques prioritize the manual collection of mature fruits from the ground or the use of extended tools to gather them from lower branches. These methods reduce harm to the trees and promote the continued vitality of neem populations (11). The differences in neem seed quality and yield between conventional and sustainable harvesting methods strongly advocate for the adoption of sustainable practices. Conventional harvesting often involves collecting immature seeds, improper handling and inadequate storage, which compromise seed viability, lower oil content and reduce overall product effectiveness. Additionally, these methods can negatively impact the neem tree's health, limiting its long-term productivity. On the other hand, sustainable practices-such as selectively hand-picking fully matured seeds during peak harvest seasons and employing eco-friendly processing techniques-yield superior quality seeds with higher oil content and efficacy. Moreover, sustainable harvesting protects neem trees from overexploitation, ensuring consistent seed production and promoting ecological balance. Transitioning to these practices not only enhances product quality and yield but also supports environmental conservation and sustainable agricultural development. The timing of seed collection plays a vital role in sustainability. Neem fruits ought to be gathered when they exhibit a yellow hue and are fully mature, generally during the summer season. This practice guarantees

the highest quality of seeds and oil content, while also permitting some fruits to stay on the tree for natural regeneration (12). Active participation of the community is crucial for the effective and sustainable collection of neem seeds for additional revenue and also for environmental conservation.

Informing local communities about proper harvesting techniques and the long-term benefits of sustainable practices. Additionally, creating equitable trade relationships and offering economic incentives for sustainable collection can encourage communities to embrace and uphold these practices (13). The adoption of sustainable practices for neem seed collection can guarantee a consistent availability of premium seeds for diverse uses, all while maintaining the ecological health of neem forests. This strategy enhances environmental preservation and strengthens the economic well-being of rural communities that rely on neem resources (14). This study aims to examine the socio-economic factors influencing the participation of rural households in neem seed collection, focusing on the livelihoods of neem seed collectors.

Materials and Methods

To fulfil the study's objective, primary data were gathered through personal interviews conducted with a designed interview schedule. The questionnaire was carefully crafted and administered to consumers in the designated regions of the Sivagangai District. The total sample size consisted of 160 participants and primary data collection occurred between May 2024 and June 2024.Out of the 12 blocks of Sivagangai district, 4 villages were selected due to the high number of neem seed collectors (Singampunari, Thiruppathur, Devakottai and Karaikudi). The members were selected only in rural areas. Based on statistical consideration, 160 sample respondents 40 respondents each from four blocks (Singampunari, Thiruppathur, Devakottai, Karaikudi)

Analytical tools

Factor analysis

Factor analysis is a valuable tool for reducing a large number of variables into a more manageable set of components. This technique identifies the shared variance among variables and condenses it into a single score, which can be utilized as a comprehensive index for all factors in future research. It operates within the general linear model (GLM) framework, assuming a linear relationship, absence of multicollinearity, inclusion of relevant variables and a genuine correlation between variables and factors. Principal component analysis (PCA) is the most widely used method in factor analysis, providing multiple options for mathematically representing a group of variables (X1, X2, ..., Xk) in terms of a smaller number of underlying factors. This approach helps to uncover the relationships and patterns among the k variables in a dataset.

$$X_i = Aij.F1 + Ai2.2F2 + Ai3.3F3 + \ldots\ldots\ldots\ldots + Aim.Fm + Vi\ Ui$$

where,

X_i= i^{th} standardized variable, where i=1,2,3,…,k variables.

A_{ij} = Standardized multiple regression coefficient of variable 'i' on common factor 'j'.

F = Common factor, where j = 1,2, 3…..m Number of common factors.

V_i = Standardized regression coefficient of variable 'i' on unique factor.

U_i = The unique factor for variable 'i'.

M = Number of common factors.

The distinct elements are unrelated to each other and to the common factors. The observed variables can be represented as a linear combination of these common components using the formula:

$$Fi = Wi1X1 + Wi2X2 + Wi3X3 + \ldots\ldots\ldots + WikXk$$

where,

F_i = Estimate of i^{th} factor.

W_i = Weight or factor score coefficient

K = Number of variables

The weights or factor score coefficients may be modified for the primary factor to account for the highest variance. If the second component is assumed not to correlate with the first, a new set of weights can be calculated to accommodate the majority of the remaining variation. This procedure is repeated for the remaining components. Consequently, factors can be estimated in such a manner that their factor scores are uncorrelated, unlike the values of the initial variables. Factor analysis was used in this study to identify the main factors influencing how neem seed collectors gather seeds. This method supports the study's objective by highlighting key challenges, such as resource access and economic conditions, that affect the collection process. These insights can help develop better strategies to improve sustainable neem seed collection practices.

Results and Discussion

Factors influencing socio-economic factors in neem seed collection

The sample respondents in this study were given eleven items (Additional revenue reason, Medicinal use, Animal feed, Neem seed cake, Neem seed oil, Environmental conservation influence, Spare time utilization, Supplementary income factor, Storage purpose, Availability of neem seed, Price of neem seed) to consider to determine the main elements influencing neem seed collection among rural people. These variables included the economic utilization factors, social responsibility factors, personal financial factors and market dynamic factors. Bartlett's test of sphericity and the Kaiser-Meyer-Olkin (KMO) measure of sample adequacy were used to assess whether the data were suitable for factor analysis. Table 1 provides the KMO and Bartlett's test details.

It could be inferred from Table 1 that the KMO measure of sampling adequacy is 0.594, which is greater than 0.5. Bartlett's test of adequacy has a chi-square value of 590.674, which is significant at 0.000 levels. Therefore, it can be concluded that, for further analysis of data, factor analysis is recommended as a suitable technique. a KMO value above 0.5 shows that the dataset has enough significant correlations among variables to justify factor analysis, with higher values reflecting stronger shared variance. Bartlett's test of sphericity

Table 1. KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.594
Bartlett's Test of Sphericity	Approx. Chi-Square	590.674
	Df	55
	Sig.	.000

determines whether the variables are sufficiently correlated by testing if the correlation matrix significantly differs from an identity matrix. A significant p-value ($p < 0.05$) indicates the presence of meaningful relationships among variables. Together, these measures confirm the suitability of the data for factor analysis, ensuring reliable extraction of key factors. This helps validate the robustness of the analysis and its outcomes.

It could be inferred from the Table 2 that the factor loadings were arrived at after varimax rotation. Factor loadings with values equal to or greater than 0.5 were considered. The second component had two factor loadings with values greater than 0.5, followed by the first, third and fourth components with two factor loadings. These components were assigned with suitable names based on their factors. By using factor analysis in SPSS the factors are grouped. Based on the grouping of the factors the components were named.

Table 2. Rotated component matrix

Rotated component matrix	Components			
	1	2	3	4
Additional revenue reason	**.751**	.146	.264	-.080
Medicinal use	**.733**	.064	-.039	.219
Animal feed	**.715**	.099	.072	-.175
Neem seed cake	**.598**	-.167	.446	-.083
Neem seed oil	**.549**	.077	-.308	.087
Environmental conservation influence	.098	**.978**	-.006	.029
Spare time utilization	.117	**.972**	.066	-.007
Supplementary income factor	-.037	.127	**.748**	.213
Storage purpose	.119	-.022	**.681**	-.056
Availability of neem seed	-.002	-.016	-.126	**.831**
Price of neem seed	-.001	.048	.413	**.747**

It could be inferred from the Table 3 that the first component was named economic utilization factors, which comprise of five factors namely, additional revenue reason, medicinal use, animal feed, neem seed cake and neem seed oil, with a variance of 24.43 per cent. This was followed by the second component, named social responsibility factors, which includes environmental conservation influence and spare time utilization, with a variance of 16.22 per cent. The third component, named personal financial factors, comprises two factors namely, supplementary income factor and storage purpose, with a variance of 14.82 per cent. Finally, the fourth component, named market dynamic factors, includes two factors namely, availability of neem seeds and price of neem seeds with a variance of 10.74 per cent.

Table 3. Component and factors

Components	Variance	Factors
Economic Utilization Factors	**24.43**	Additional revenue reason
		Medicinal use
		Animal feed
		Neem seed cake
		Neem seed oil
Social Responsibility Factors	**16.22**	Environmental conservation influence
		Spare time utilization
Personal Financial Factors	**14.78**	Supplementary Income Factor
		Storage purpose
Market Dynamic Factors	**10.74**	Availability of neem seed
		Price of neem seed

It could be evident from the factor analysis that economic utilization factors, with a variance of 24.43 per cent, were the most influential factors in neem seed collection. It could be concluded from the table that all four components played a major role in influencing the neem seed collection.

Personal factors and level of awareness on usage of neem seed formulation

Hypothesis: There is no significant difference between the personal classification of the respondents on their mean scores relating to level of awareness on the usage of neem seed formulation

The results of ANOVA in terms of personal factors, source of variation, degrees of freedom, sum of squares, mean sum of squares, F values, p values and their significance on the level of awareness on the usage on neem seed formulation are presented below in Table 4.

The ANOVA table showed that gender, education and occupation had a significant impact on the dependent variable ($p < .05$). Among these, occupation had the strongest effect ($F = 10.602$), followed by gender ($F = 9.722$) and education ($F = 3.458$). On the other hand, family size, income and ownership did not have significant effects ($p > .05$). This means that when looking at the dependent variable, it is important to consider the differences in occupation gender and education, as these are the key factors affecting the results. The hypothesis is rejected (significant) in 3 cases (gender, education and occupation) and accepted (not significant) in 3 cases (family size, income and ownership). It can be concluded that substantial differences in mean scores among individuals exist based on gender, education and occupation regarding their level of awareness on the usage of neem seed formulation.

Table 4. Personal factors and level of awareness on usage of neem seed formulation

Personal factors	Source of variation	Degree of freedom	Sum of Squares	Mean Square	F Values	P Values	Significance (S)/Not significance (NS)
Gender	Between Groups	4	2.726	.682	9.722	**.000**	**S**
	Within Groups	15s5	10.867	.070			
	Total	159	13.594				
Education	Between Groups	4	1.114	.278	3.458	**.010**	**S**
	Within Groups	155	12.480	.081			
	Total	159	13.594				
Family size	Between Groups	2	.273	.136	1.608	**.204**	**NS**
	Within Groups	157	13.321	.085			
	Total	159	13.594				
Occupation	Between Groups	3	2.302	.767	10.602	**.000**	**S**
	Within Groups	156	11.292	.072			
	Total	159	13.594				
Income	Between Groups	3	.083	.028	.319	**.812**	**NS**
	Within Groups	156	13.511	.087			
	Total	159	13.594				
Ownership	Between Groups	2	.001	.001	.009	**.991**	**NS**
	Within Groups	157	13.592	.087			
	Total	159	13.594				

Conclusion

Further, it is concluded that the economic utilization factor (additional revenue reason, medicinal use, animal feed, neem seed cake, neem seed oil) majorly influenced neem seed collection, with a variance of 24.43 per cent. The ANOVA table concluded that the hypothesis is rejected (significant) in 3 cases (gender, education and occupation) and accepted (not significant) in 3 cases (family size, income and ownership). It concluded that. Substantial differences in mean scores among individuals based on gender, education and occupation were observed regarding their level of awareness on the usage of neem seed formulation.

The findings of this study provide valuable insights that can guide future research and inform policies on neem seed collection and awareness of its formulations. Future studies could delve deeper into specific regional challenges faced by collectors, such as economic limitations, resource scarcity and environmental impacts, to create more tailored and effective solutions. These findings also offer a basis for developing policies that encourage sustainable harvesting practices, ensuring the health and productivity of neem trees while enhancing seed quality and yield. Moreover, awareness initiatives could educate local communities and collectors about the advantages of sustainable methods and the wide-ranging applications of neem-based products in agriculture, healthcare and other industries. By aligning research, policy and education, these efforts can improve neem seed collection processes, support sustainable livelihoods and contribute to environmental conservation.

Acknowledgements

This research is a testament to the collective effort and collaboration of everyone involved and I sincerely thank my advisors and colleagues for their invaluable support, guidance and encouragement throughout this research. Their insights were crucial in shaping and completing this work and I also applaud all the staff and peers who helped in various capacities.

Authors' contributions

SA contributed by collecting literature and writing the manuscript. IVM assisted in securing research funds, editing, summarizing and revising the final manuscript. MS approved the manuscript, while KM and SS provided support in summarizing and revising the manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interest to declare

Ethical issues: None

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the authors used Gemini AI to improve language. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

References

1. Rahal A, Kumar D, Malik JK. Neem extract. Nutraceuticals in Veterinary Medicine. 2019:37-50. https://doi.org/10.1007/978-3-030-04624-8_3
2. Bijalwan A, Dobriyal MJ, Chaudhry P. Biosciences and plant biology. Int. J. Curr. Res. Biosci. Plant Biol. 2017;4(1):102-04. https://doi.org/10.20546/ijcrbp.2017.401.011
3. Lokanadhan S, Muthukrishnan P, Jeyaraman S. Neem products and their agricultural applications. Journal of Biopesticides. 2012; 5:72. https://doi.org/10.57182/jbiopestic.5.0.72-76
4. Alzohairy MA. Therapeutics role of *Azadirachta indica* (Neem) and their active constituents in diseases prevention and treatment. Evidence-Based Complementary and Alternative Medicine. 2016;2016(1):7382506. https://doi.org/10.1155/2016/7382506
5. Kundu PI, Barik SU, Sarkar KO, Bose AN, Baral RA, Laskar SU. Chemical investigation of neem leaf glycoprotein used as immunoprophylactic agents for tumor growth restriction. Int. J. Pharm. Pharm. Sci. 2015; 7:195-99.
6. Roshan A, Verma NK. A brief study on neem (*Azardirachta indica* A.) and its application- A review. Research Journal of Phytomedicine. 2015;1(1):01-03.
7. Islas JF, Acosta E, Zuca G, Delgado-Gallegos JL, Moreno-Treviño MG,

Escalante B, Moreno-Cuevas JE. An overview of Neem (*Azadirachta indica*) and its potential impact on health. Journal of Functional Foods. 2020; 74:104171. https://doi.org/10.1016/j.jff.2020.104171

8. Anjali Tiwari AT, Ankit Pandey AP, Verma OP. Phytochemical screening of *Ocimum sanctum* (Tulsi), *Azadirachta indica* (Neem) and *Phyllanthus emblica* (Amla). Roychoudhury R. Neem products. In Ecofriendly pest management for food security 2016 Jan 1 (pp. 545-562). Academic Press. https://doi.org/10.1016/B978-0-12-803265-7.00018-X
9. Roychoudhury R. Neem products. In Ecofriendly pest management for food security 2016 Jan 1 (pp. 545-562). Academic Press.
10. Koul O, Isman MB, Ketkar CM. Properties and uses of neem, *Azadirachta indica*. Canadian Journal of Botany. 1990;68(1):1-1. https://doi.org/10.1139/b90-001
11. Orwa C. Agroforestree Database: a tree reference and selection guide, version 4.0. https://apps.worldagroforestry.org/treedb/
12. Puri HS. Neem: the divine tree *Azadirachta indica*. CRC Press; 1999 Mar 25. https://doi.org/10.1201/9780203304310
13. Kumar J, Parmar BS. Physicochemical and chemical variation in neem oils and some bioactivity leads against *Spodoptera litura* F. Journal of agricultural and food chemistry. 1996;44(8):2137-43. https://doi.org/10.1021/jf950283s
14. Schmutterer H. Properties and potential of natural pesticides from the neem tree, *Azadirachta indica*. Annual review of entomology. 1990;35(1):271-97. https://doi.org/10.1146/annurev.ento.35.1.271