# The State of ORGANIC FARMING in TAMIL NADU

## Bridging Farmer Practice, Knowledge and Research


TNIVK

VAF
VikasAnvesh Foundation

INDIAN INSTITUTE OF TECHNOLOGY BOMBAY

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Siva Muthuprakash K M and Om Damani

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*Authors*

Siva Muthuprakash K M and Om Damani

*Contributors*

Karthik Gunasekar, Nivedita Ramanan, Siva Kumaran N.D.

*Organizations*

**VikasAnvesh Foundation (VAF)** is a unique research Centre working on key and often neglected development issues faced by rural communities and grassroots workers. VAF engages in development research on issues that have high practical relevance and specifically address felt and articulated problems of development fraternity and grassroots' agencies rather than disciplinary and theoretical adherence. It aims to contribute to action and practice while simultaneously contributing to knowledge creation.

**Tamil Nadu Iyarkai Velan Koottamaipu (TNIVK)** is a collective working on promoting organic agriculture in TN. The collective has organic farmers, civil society organizations, farmer producer organizations, social enterprises, academic institutions, academicians, activists, women's groups, individual experts in organic farming, seed conservator groups and consumer organizations etc. While each of them is already working on their own initiatives, TNIVK's effort is to collectively strengthen and streamline the organic agriculture movement in Tamil Nadu.

**Indian Institute of Technology Bombay (IITB)** is a public research university and technical institute in Mumbai, Maharashtra, India. Established in 1958, IIT Bombay was designated as an Institution of Eminence in 2018. **Technology and Development Solutions Cell (TDSC)** is a resource centre for providing technology-based solutions for the development sector. TDSC offers technical consulting services on projects serving the bottom 80% in the basic sectors of water, energy, sanitation, healthcare and agriculture.

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*List of organic farmers participated in the study*

| Cuddalore | Salem |
|---|---|
| Aravazhi, Vadalur | Aravindan, Salem |
| Bharath Kumar, Guruvanpettai | Chandrasekar L, Suramangalam |
| Mahesh, Vilagam | Palanimalai, Nangavalli |
| Murugan, Murugankudi | Prakash, Elampillai |
| SivaRama Sethu, Guruvanpettai | Ramakrishnan, Salem |
| Suresh, Chidambaram | Sanmugam, Chettiyur (Mettur) |
| **Chengalpattu** | Senthil, Nangavalli |
| Alladi Mahadevan, Nerkunampattu | **Dindigul** |
| Iraiazhagan, Thirukazhukundram | Ajay Kuruvilla, Sriramapuram |
| Jayachandran, Ariyalur (Cheyyur) | Arvindan, Kalpattisathiram |
| Subbu, Cheyyur | Asraf Ali, Sirumalai |
| **Pudhukottai** | Augustine Selvaraj, Vangomanuthu |
| John, Arimalam | Kandhavelu Jeyalekshmi, Velansevaikaranpati |
| Kumar, Vellaipillaiyarpatti | Kadhar Meeran, Sithaiyankottai |
| Muniyan, Lakshmanapatti | Kuzhandhaivel, Reddiyarchathiram |
| Nisha (Nisha Organic), Veppankudi | M. Jayaganesh, Kamapatti |
| Vijay Raghavan, Arimalam | Periyasami Rajeshwari, Nagapanpettai |
| **Tiruppur** | Ponselvaraj, Dindigul |
| Balaji, Madhapur | Ramkumar, Selapatti |
| Krishna Bharathi, Bhavani | Regan, Dindigul |
| Navaraja, Angapa Gowndamputur | Ruban, Dindigul |
| Ponmuthu, Kirandmuthur | Sangeetha and Bala, Dindigul |
| Prabakaran, Avinashi | Selvi, Reddiyarchathiram |
| Prabhaharan, Vellampalayam | Vellaisami, Dindigul |
| Senthil Chamundeeswari, Bhavani | Vijay Bharathi, Sithaiyankottai |
| Suresh, Ramagoundampallayam | Vetrimaran R, Nilakottai |
| **Tanjavur** | **Coimbatore** |
| Anbuselvam, Guruvadipatti | Senthil Kumar, Sulur |
| Dhanapal, Seeralur | **Madurai** |
| Dr. Puniamoorthy, Tanjavur | Nityanand, Madurai |
| Elango, Tanjavur | Bala Subramanian (Pamayan), T.Kallupatti |
| Vijay, Tanjavur | |

# 1. Table of Contents

# Summary

Organic farming in Tamil Nadu is a vibrant and fast-evolving ecosystem characterized by the expertise and innovative practices of farmers at the production level, complemented by a diverse range of community engagement and collaborative approaches for successful market linkage. Through in-depth field interviews with over 50 experienced organic farmers across ten districts, we capture the diversity of practices, motivations, and operational models shaping organic farming in Tamil Nadu. These organic farmers in Tamil Nadu demonstrate remarkable adaptability and innovation as they keep evolving new strategies both in production and market ends. They blend traditional knowledge with modern tools, build peer networks for knowledge exchange, experiment with formulations and cropping systems, create alternative market mechanisms and maintain economic pragmatism while pursuing ecological and social goals.

The seven operational designs of organic farmers identified across the districts represent differentiated pathways through which farmers organize production and market engagement, highlighting that organic transition in Tamil Nadu is not uniform but structurally diverse and responsive to the context. The emerging operational design groups include collective and cooperative models (30% of farmers), value addition with direct consumer engagement (30%), supplementary income/hobby farming (20%), agro-ecology trainer farms (10%), allied service model, organic farming as lifestyle and “search for light”. These designs reflect diverse pathways for economic viability and sustainability, with implications for designing differentiated support strategies. The identification of "search for light" farmers who are practicing organic methods but trapped between conventional markets and organic networks highlights a critical vulnerability group requiring targeted intervention.

Over 30 distinct organic formulations and practices covering soil nutrient management and, pest and disease management practices adopted and refined by experienced organic farmers, are compiled and analysed. For each practice, we document, (1) the underlying concept and principles as understood by farmers and available scientific literature, (2) core composition including ingredient ranges and process parameters across multiple practitioners, (3) diversity and variations reflecting regional adaptations and individual innovations, and (4) notable observations highlighting sophisticated farmer understanding and experimental approaches. This documentation represents actual state of organic farming as practiced and adapted by farmers in Tamil Nadu.

These practices are contextualised within formal research and the findings from peer-reviewed scientific literature. We identify where farmer practices align with scientifically validated mechanisms and compounds, highlight innovative farmer adaptations that extend beyond current scientific documentation, reveal critical research gaps where valuable farmer practices need to be studied, and provide reference-based benchmarks

where available in literature, creating a comprehensive resource that bridges farmers knowledge and contemporary agricultural science.

To better understand the relationship between farmer innovation and formal scientific validation, the documented practices were grouped according to the strength and nature of available scientific literature. The resulting Practice-Science Matrix given below maps the current state of research documentation of 27 practices analysed along with their implication and priority areas to advance the agro-ecological knowledge system.

| Evidence Category | Scientific Literature | Implication for Scaling | Priority Action |
|---|---|---|---|
| **Strong and robust (like green manuring, enriched compost, neem-based formulations, physical traps) (5/27)** | Multi-location field trials; long-term soil and yield studies; replicated agronomic research | Scientifically robust; ready for wider promotion with contextual adaptation | Dissemination, farmer training, district-level demonstration plots |
| **Moderate, limited field studies (like jeevamirtham, panchagavyam, meenamilam, EM karaisal) (12/27)** | Some field studies + microbiological or crop-level experimental validation | Widely practiced; evidence supports ecological logic but lacks long-term studies | Multi-season field trials and impact characterisation |
| **Weak, indirect evidence (like poochiveratti, agnihastra, 3G karaisal) (7/27)** | Studies validate ingredients (e.g., garlic, chilli, vitex. etc.) but limited trials on full formulation | Ecologically sound; practice-rich but under-tested as composite formulations | Controlled field bioassays; synergy studies; pest–crop specificity trials |
| **Marginal, Practice-led (like vella velan pattai karaisal, karpura karaisal) (3/27)** | Limited or no direct trials; mostly experiential knowledge | Innovation space; constrained by lack of formal documentation | Participatory research and practice documentation |

The evidence landscape suggests that organic farming in Tamil Nadu is dynamic and practice innovation frequently outpaces formal scientific validation. Several widely adopted formulations occupy a space where farmer experience demonstrates perceived reliability and ecological coherence, yet structured, multi-season research remains limited or fragmented. Nutrient management practices show stronger alignment with existing scientific literature, whereas pest and disease management practices demonstrate a higher degree of farmer-led innovation relative to formal validation. Pest and disease management practices operate within a higher-risk decision environment where farmer livelihoods are acutely exposed. The relative lag in scientific literature of ecological pest management systems therefore represents not only a knowledge gap but a structural vulnerability with direct livelihood implications, requiring participatory research and institutional support. Research prioritisation needs to focus on ecological pest management systems for de-risking the farmers with enhanced knowledge ecosystem for a smooth transitioning into agro-ecological practices.

The Practice-Science Matrix highlights productive opportunities at both the end of knowledge and practice rather than a deficit. While scientific literature provides farmers with detailed and peer-validated protocols for cross-learning; practices with high farmer adoption but limited documentation represents valuable, field-tested hypotheses emerging from real-world experimentation. They offer a strong foundation for participatory trials, field studies, and protocol refinement. Strengthening structured dialogue between farmer innovation and scientific inquiry can transform localized experiential successes into widely accessible agro-ecological knowledge while preserving the adaptive, context-sensitive character that defines organic farming systems. Thus, systematic documentation of farmer-led practice is not an endpoint, but the institutional starting point for a collaborative and iterative knowledge-building process between farmers, researchers, and policy systems. Extending similar state-level practice documentation and evidence mapping across other regions of India would create a national baseline of agro-ecological practice maturity, helping identify high-risk knowledge gaps, align research investment with field realities, and design differentiated institutional support systems.

# 1. Background

The growing concerns around farm sustainability have led to increased focus on soil health, natural resource management, and climate-resilient farming. Farmers face challenges from volatile commodity prices, rising cultivation costs, and the health impacts of chemical-intensive agriculture. Meanwhile, consumer awareness about safe and toxin-free food is growing, yet access remains limited to niche markets. Government programs at both Central and State levels have incorporated agro-ecological farming, but large-scale adoption remains a challenge.

Despite decades of work by civil society organizations (CSOs), agro-ecological initiatives often stagnate due to systemic gaps in knowledge sharing, input accessibility, and market linkages. While some farmers have successfully transitioned to sustainable farming, a broader strategic approach is needed to facilitate this shift at scale. This study which aims to assess and strengthen the agro-ecological farming ecosystem, with a focus on three critical challenges identified by practitioners and promoters of agro-ecological farming which includes knowledge synthesis, farm input systems, and market linkages.

## 1.1 About the study

This study seeks to develop a State of Organic farming Ecosystem Report to guide sustainable transition strategies. Unlike existing sector reports that focus primarily on production, this research adopts a holistic perspective, assessing knowledge systems, input accessibility, market linkages, and policy support across multiple states. The study is informed by extensive stakeholder discussions with farmers, trainers, researchers, and market actors through Tamil Nadu Iyarkai Velan Kootamaippu (TNIVK). The research is structured around three key objectives:

1. **Phase 1 - Knowledge Synthesis:** Compilation and analysis of diverse agro-ecological farming practices to create a cross-learning resource for farmers and stakeholders.
2. **Phase 2 - Scanning of Support Ecosystem:** Assessment of government schemes, programs, and availability of organic farm inputs across selected districts.
3. **Phase 3 - Understanding Consumer Characteristics:** Evaluation of consumer preferences, price sensitivity, and market potential to align organic production with demand.

The study follows a mixed-methods approach, combining desk research, surveys, and field studies. Knowledge Synthesis is largely based on Compilation and comparative analysis of agro-ecological practices adopted by trainer and expert farmers and published scientific literature. Support Ecosystem Assessment is desk-based mapping of government schemes supporting agro-ecological practices, followed by field surveys to evaluate local access to organic inputs and market linkages. Consumer Behaviour Analysis is based on interviews with organic food retailers and distributors, along with an online consumer survey to assess demand trends.

The study is designed in collaboration with voluntary networks, CSO networks, with field research anchored by lead organizations in each state. Special emphasis is placed on capturing insights from farmers with limited institutional engagement, ensuring that findings contribute to practical and scalable interventions.

## 1.2 About this report

This report provides a synthesis of findings and outcomes from the Phase 1 of the study under the state of organic farming in Tamil Nadu. The report opens with an introduction that outlines the purpose, scope, and significance of this study on organic farming. It highlights the key questions driving the larger research and provides an overview of the methodology adopted for data collection and analysis. This section sets the broader context for understanding the current state of organic farming in India. It presents a landscape scan of agro-ecological farming typologies across different regions, highlighting rich knowledge and diversity in farming practices. This review serves as a foundation for situating organic farming within the broader framework of sustainable agricultural transitions in India.

Following the introductory sections that establish the broader landscape of agro-ecological farming in India, the report presents the ecological principles that frame the organic farming ecosystem in Tamil Nadu. This contextual foundation helps situate farmer practices within wider debates on sustainability, agricultural transitions, and knowledge systems.

The subsequent sections present the field study findings, beginning with sample characteristics and farmer profiles, followed by analysis of motivations, operational models, and distinctive attributes of agro-ecological farmers. The core of the report is the knowledge synthesis section, which documents farmer-led practices related to soil fertility and pest and disease management. Each practice is described through a structured framework covering principles, composition, process variations, and scientific references, thereby creating a bridge between experiential farmer knowledge and formal research. The report concludes with reflections that contribute to building a broader organic farming ecosystem framework for future phases of the study.

# 2. Landscape of agro-ecological farming

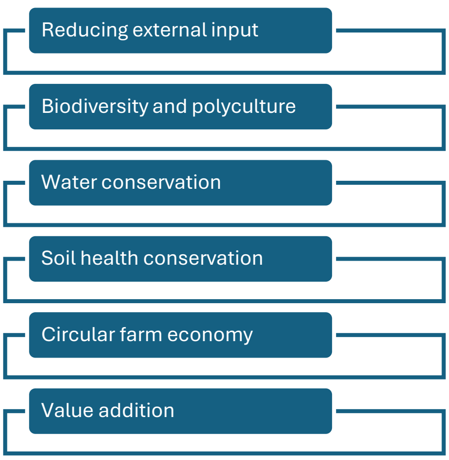
Agro-ecological farming is gaining prominence in India as a sustainable alternative to conventional chemical-based agriculture. With rising concerns over soil degradation, water scarcity, loss of biodiversity, and the economic distress of farmers, agro-ecological methods present a holistic approach that aligns with ecological balance and rural livelihoods. In this section an effort is made to compile and document various agro-ecological farming methods practiced across India, analyze their key components, and provide a foundation for understanding the broader organic farming ecosystem in the country. Annexure 1 gives the detailed compilation of diverse agro-ecological typology and salient features of the practices. The insights gathered here will contribute to a larger report aimed at mapping and assessing the landscape of organic farming in India.

This compilation is based on desk research, drawing from various sources including research papers, government reports, civil society initiatives, and farmer experiences. The focus has been on identifying methods that are already being practiced, their underlying principles, and their impact on soil health, biodiversity, water conservation, and farmer incomes. The analysis also takes into account the socio-economic feasibility and scalability of these practices, with an emphasis on their adaptability across different agro-climatic zones.

This table illustrates the strength of Indian agriculture with its vast and diverse landscape of agro-ecological farming methods, shaped by traditional wisdom, regional climates, and modern adaptations. These methods reflect a spectrum of farming practices that range from traditional organic techniques to scientifically articulated recent approaches. The diversity of these approaches allows farmers to select models that best align with their agro-climatic conditions and available resources.

## 2.1 Common Ecological Principles

Despite their diversity, these farming methods share core ecological principles that make them distinct from conventional chemical farming. These principles create a foundation for sustainable agricultural practices, ensuring that ecological processes such as nutrient cycling, water conservation, and biodiversity are maintained and enhanced. Understanding these commonalities helps in designing frameworks for scaling agro-ecological farming.




- Minimal external inputs: Most agro-ecological methods reduce or eliminate chemical fertilizers and pesticides, focusing instead on natural cycles of fertility.

- Soil health improvement: Through composting, mulching, cover crops, and microbial activators, these methods enhance soil organic matter, microbial diversity, and nutrient retention.
- Water conservation: Techniques such as deep-rooted perennials, mulch-based moisture retention, and localized irrigation enhance water efficiency.
- Biodiversity and polyculture: The integration of multiple crop varieties, agroforestry elements, and livestock creates resilient farm ecosystems, reducing pest outbreaks and increasing productivity.
- Circular farm economy: Waste recycling, manure-based fertilizers, and integrating multiple farm components ensure resource efficiency and sustainability.
- Value addition: Many models emphasize the importance of participation of farmers in value addition process for a deeper producer-consumer relations and better economic returns.

By contextualizing these farming methods within a systemic framework, the upcoming report will contribute to strengthening the organic farming movement in India, offering evidence-based recommendations for policy, practice, and market interventions. This compilation serves as a stepping stone towards deeper engagement with the subject, leading to actionable insights for strengthening the ecosystem of organic farming.

While the above landscape illustrates the diversity of agro-ecological models practiced across India, such typological mapping alone does not reveal how these principles are interpreted, adapted, and operationalized within specific regional contexts. Agro-ecology, by its very nature, is locally embedded and shaped by agro-climatic conditions, resource availability, cultural traditions, and market realities. Tamil Nadu presents a particularly dynamic case where farmer-led experimentation, collective initiatives, and diverse operational models intersect within a rapidly evolving ecosystem. To move from broad ecological principles to grounded practice realities, the study therefore turns to an in-depth field-based exploration of experienced organic farmers across districts. The following section introduces the sample characteristics that form the empirical foundation for understanding how agro-ecological principles are translated into practice within the state.

# 3. Farmer characteristics

## 3.1 Sample design

Over fifty experienced farmers across ten districts in Tamilnadu was interviewed to understand the key management practices in their agro-ecological farms. While each of these farmers were interviewed at their farm, a few expert farmers from other districts like Coimbatore, Tenkasi and Thiruvallur were interviewed over online conference calls. Efforts were made to cover farmers from different villages within each of the district to bring diversity in the farming practices. Table 1 below provides an overview of number of farmers interviewed in person from each district along with the villages covered and key crops cultivated by the farmers.

***Table 1 Sample coverage***

| District | Villages | Crops Discussed |
|---|---|---|
| Cuddalore (7) | Chidambaram, Kezha Perumbai, Murugankudi<br>Vadalur, Guruvanpettai<br>Guruvanpettai, Vilagam | Paddy, green gram, sesame, black gram, groundnut and vegetables |
| Salem (6) | Chettiyur, Nagarvalli, Elampillai, Suramangalam, Salem | Banana, coconut, mango, sugarcane, groundnut, tomato, turmeric, arecanut, pepper, onion, cotton, millets, green gram, and other vegetables |
| Chengalpattu (4) | Cheyyur, Ariyalur, Koovathur, Valavanthangal, Chengalpaatu | Mango, coconut, cashew, groundnut, sesame, black gram, millets and paddy |
| Tiruppur (8) | Jambhai, Angapa Gowndamputur, Avinashi<br>Palladam, Vellampalayam, Ramagoundampallayam, Madhapur | Sugarcane, turmeric, paddy, sesame, coconut, banana, mango, jackfruit, custard apple, papaya, gooseberry, vegetables and pulses |
| Tanjavur (4) | Guruvadipatti, Seeralur,<br>Vallam, Thethuvasalpatti | Paddy, drumstick, vegetables, coconut, mango, jackfruit, guava, lemon and pulses |
| Pudhukottai (5) | Vandakottai, Arimalam, Thiruvarankulam, Lakshmananpatti, Vellapillaiyarpatti | Paddy, groundnut, black gram, sesame, vegetables, coconut, banana, red sesame, pulses, fruits |
| Dindigul (15) | Sriramapuram, Nagapanpetai, Velanservaikaranpatti,<br>Sithaiyankottai, Sempatty<br>Sirumalai, Reddiyarchathiram, Vangomanuthu, Reddiyarchathiram,<br>Sirumalai, Kamapatti,<br>Kalpattisathiram, Dindigul, Selapatti,Nilakottai | Paddy, pulses, groundnut, sugarcane, vegetables, fruit trees (guava, sapota, mango, jackfruit, drumstick, banana, etc.), coconut, millets |

## 3.2 Farmer and farm profile

In order to give the context of various agro-ecological practices adopted by the farmers, a few key characteristics of farmers and farms were captured. The farmer sample comprised 45% marginal and small farmers, 33% medium farmers, and 22% large farmers. While all the farmers covered under the study had access to irrigation, a few farmers from Salem district and Dindigul district cited limitation in water availability in case of monsoon failure for successive years. Table 2 below gives an overview of various social-economic context of the farmers along with a few other characteristics defining their approach to their farm management.

The extent of income diversification was strongly linked to farm size where only 23% of marginal and small farmers had significant non-farm income sources, compared to 69% among medium farmers and 82% among large farmers. A similar pattern is visible among farmers with “limited or no dependence on farming” as livelihood as only 14% of marginal and small farmers fell into this category, compared to 44% for medium farmers and 82% for large farmers. Interestingly, concern about farming was highest among medium farmers (50%) and marginal and small farmers (27%), but absent among large farmers.

In terms of production orientation, value addition was most common among marginal and small farmers (59%) and medium farmers (56%), suggesting that these groups see post-harvest activities as a way to enhance income from limited land. Large farmers were less engaged in value addition (27%), due to a focus on scale rather than product differentiation. Direct marketing to consumers was found to be a critical enabler for many agro-ecological farmers and it was highly prevalent across all groups but especially strong among large farmers (91%) and marginal and small farmers (77%), indicating the strong market channels of these farmers interviewed.

***Table 2 Characteristics of the farmers***

| | **Significant other income source** | **Limited or No Dependence on Farming** | **Concern expressed on farm production** | **Attention to productivity** | **Value addition** | **Direct Market to consumers** |
|---|---|---|---|---|---|---|
| Marginal and small farmers | 23% | 14% | 27% | 59% | 41% | 77% |
| Medium | 69% | 44% | 50% | 56% | 81% | 69% |
| Large | 82% | 82% | 0% | 27% | 64% | 91% |
| Overall | 100% | 59% | 41% | 34% | 58% | 73% |

The sample indicates that smaller farmers are more dependent on agriculture for their livelihoods, which may make them more cautious in adopting unfamiliar agro-ecological practices, while larger farmers less dependent on farm income may have more flexibility to experiment. The data also reveals that farm size influences livelihood dependence, production strategies, and market engagement in distinct ways. Marginal and small farmers tend to be more dependent on agriculture yet are active in value addition and direct marketing, which could make them strong adopters of agro-ecological practices if risks are addressed. Medium farmers balance income diversification with productivity concerns, making them a key target group for scaling such practices. Large farmers, while less dependent on farming, have strong consumer market linkages that could be leveraged to create demand for agro-ecologically grown produce.

# 4. Drivers of organic farming in Tamil Nadu

Following the context of the farm and farmers, it is desirable to understand the motivation to adopt organic farming and the individual's approach towards farming in large. Comprehensive qualitative interviews conducted with farmers and trainers throughout Tamil Nadu provided insight into various motivational factors, operational design and the evolving strategies adopted by organic farmers. Several key design qualities emerged, offering a deeper understanding of not only their agricultural practices but also their underlying philosophies and attitudes toward farming.

## 4.1 Motivation

The motivational factors for adopting organic or agro-ecological farming, observed across the farmers could be broadly grouped under six factors listed in the order of relevance. The six factors include health (family and consumer health), soil and environment, self-reliance, economic opportunity, personal transformation and community empowerment.

Health concerns were one of the most frequently cited drivers, often among those who experienced health issues in their families or closely associated people, which lead to a decision to produce safer food to people. Numerous farmers shared several detailed incidents as old as two decades back to last couple of years, which has made everlasting impact on their life and livelihood.

Many farmers cited soil degradation, desire to rejuvenate soil fertility, and environmental restoration as core reasons for transition. Several farmers highlighted the negative impact of chemical inputs on soil and the positive impact of organic practices on soil health, biodiversity, and ecosystem resilience.

Self-reliance was an important factor for those interested in conserving indigenous seeds, minimizing external dependencies, and keeping traditional practices alive. Several farmers are actively engaged in seed saving, input preparation, and local experimentation.

Several farmers engaged in or initiated farmer groups, collective marketing, seed festivals, and knowledge-exchange activities. This motivation often overlapped with others, especially when farmers sought to build resilient, self-sustaining communities.

Some farmers cited personal values, inspiration from well-known figures (like Namalvar or Subash Palekar), or a philosophical commitment to living in harmony with nature as the central reason for their transition.

In a few cases, reduced input cost and market opportunity were cited as a trigger to shift towards organic farming. Some farmers were motivated by direct marketing, collective selling, and better price realization, especially after experiencing market-related challenges and losses. Further, several farmers cited the reduction in input cost as an advantage to organic farming rather than a key motivation to adopt organic farming practices.

## 4.2 Operational designs

Organic farmers across Tamil Nadu employ a broad spectrum of operational designs, evolving and adapting their approach to local environment, resources, socio-economic needs and personal values. Their approaches draw on tradition, scientific experimentation, community engagement, and a spirit of innovation. A typology of design was synthesized based on the interviews to broadly group the range operational design adopted by the farmers. Value addition with direct consumer model, small collective and cooperative models, and supplementary income model are the prominent operational design observed among the farmers. Several other designs like agro-ecology trainer model, allied service model, organic farming as lifestyle designs, and search for light scenarios were also observed on relatively smaller proportion.

### 4.2.1 Collective and Cooperative Models

The collective and cooperative model revolves around farmers coming together to form organized informal groups or formal associations. These collectives aim to pool resources, bring diversity in farm produce, streamline production and marketing, and achieve greater market reach and bargaining power than individuals could do alone. Close to 30% of the farmers covered under the study come under this operational model.

For example, a group of 10-15 farmers have come together to form Sivan Organic Sandhai in Tirupur district. Initiated by couple of farmers in Uzhavar Sandhai (farmer market regulated by the local govt. bodies.) over 5 years back, the group has grown to set up their own private market exclusively for organic produce catering to over 300 regular consumers across three weekly markets in three different locations. Similarly, a group of about 15 farmers in Dindigul organizes Dindigul organic market on a weekly basis for over five years focusing on perishables esp. fruits and vegetables. In Chidambaram, CAAAP is evolving into a more formal collective focusing on non-perishables like rice, pulses, millets and oil seeds.

The key features observed in such collectives include

- Strong emphasis on collaboration and resource sharing within the group.
- Facilitate collective marketing and shared learning, giving members stable access to markets and technical support.
- Distinct from other models in their formalized structures, enabling wider reach and greater scale.
- Compared to self-sufficient or hobby models, these groups are more outward-facing and market-driven.

### 4.2.2 Value Addition and Direct Consumers

This is often the most prominent and independent model which emphasizes processing and direct marketing with the centrality of allowing farmers to capture greater value and build closer relationships with consumers. This model is driven by individual farmers who are often self-motivated based on own experience or leaders, pursuing organic farming with very limited external support. This set of farmers largely depends on self learning and independent consumer niche for marketing. These farmers are often found to market their own produce directly at stalls, personal networks and through online channels. With over 30% of the farmers studied falling under this group, this model is the most prevalent approach with numerous farmers like Aravazhi in Cuddalore, Muniyan in Pudhukottai, Dhanapal in Tanjavur, etc., adopting this operational design.

Key Features for this set of farmers include

- Emphasis on diversification of income streams beyond raw produce sales like value added products.
- Active consumer engagement, networking for consumer reach, and adoption of technology for marketing.
- Often collaborate with neighboring organic farmers to meet demand and supply.

### 4.2.3 Organic Farming as a Hobby or Supplemental Venture

Backed by an alternate source of income and economic stability, these are individuals or families practicing organic farming for personal interest, recreation, or as a supplementary income and food source rather than a main livelihood activity. Most of the farmers under this group have substantial economic security from their past jobs, businesses, or other family income. Many of these farmers attempts to build model organic farms with high biodiversity, minimal external inputs, and resilience through design. Distinct from full time farmers, their focus is on farm ecology over market scale and tend to look for long term returns and limited attention on short term viability. While many of them pursue farming like a leisure activity, some are actively engaged in the farming activity in an effort to meet their financial needs from organic farming. Further, some of these farmers have developed the farm focusing on eco-tourism and recreational purposes. About 20% of the farmers covered under the study come under this group.

The key features observed by farmers under this group are

- Adopt both traditional and modern techniques, often influenced by short-term training or digital media.
- Highly experimental in approach with limited concern on crop yield and production.
- Highly biodiverse cropping designs with horticulture, plantation and field crops.
- At times, these farmers provide an anchoring role to a group through their network both to market and government.

### 4.2.4 Agro-ecology trainer farms

These are often pioneering farmers whose livelihood is largely dependent on farming, and their farms are designed to be used for training and educational purposes. Most of these farmers act as resource person for trainings and engage in organizing training programs, workshops and field visits through institutions and networks. Often these farmers act as a nodal point for knowledge sharing and reach to a larger set of organic farmers in the region. About 10% of the farmers in the study come under this category.

The key features of these farmers are

- Strong networks for continuous knowledge exchange and support.
- High influence on the wider farming community, spreading best practices beyond their own operations.
- Distinct from market and production-focused models by their outward educational mission and collaborate at times.

### 4.2.5 Allied service model

A relatively smaller proportion of organic farmers who integrate an essential organic farming related service along with their organic farming activity to strengthen their income as well as fill the gap in organic farming local ecosystem. Saving and sharing seeds of indigenous varieties of crops is one of the popular activity among these farmers. Mass production and sale of organic formulations like panchagavya, illai karaisal (plant extract), cyanobacteria, etc. is the other activity which is prevalent among small holder farmers. Farmers like Subbu in Chengalpattu and Deiva/Sanmugam in Salem come under this group.

Key features of these farmers are

- Household income and livelihood depend on organic farming and allied activity.

- Often a small-scale farmer with subsistence farming.
- Highly knowledgeable in organic farm practices and occasional trainers

### 4.2.6 Organic farming as lifestyle

A small portion of farmers view organic farming as a holistic and self-reliant way of life where they strive for near-complete independence in food, inputs, and energy, deeply integrating family and community into daily agricultural routines. Often these are farmers who had either quit a mainstream job at early career phase or started their career highly influenced by stalwarts like Namalwar. They have some characteristic of each of the group discussed above like engaging in seed saving and sharing, occasional trainer, cater to a small niche of market, operate with interest groups connected with organic farming, and build highly diversified and model farm for self-sufficiency. A few farmers like Ramkumar in Dindigul and Vijay in Tanjavur come under this group.

The key features of these farmers are

- Farmers are more inwardly focused, prioritizing self-reliance over commercial production.
- Relatively smaller farms with strong emphasis on resource recycling and sustainability.
- Active experimentation and knowledge sharing often distinguish these farmers to become local icons.
- Highly resourceful and potential trainers for the future.

### 4.2.7 Search for light

Several farmers surveyed for the study has not fully transitioned or have become viable financially. They often find themselves in a complex and often precarious middle ground striving to practice organic methods but remain deeply entangled with conventional markets for both farm inputs and produce.

Farmers such as Prakash depend heavily on the availability of organic inputs, bio-fertilizers, pest repellents, and seeds purchased from the open market rather than produced on-farm. This reliance on market based organic input increases the cost of cultivation significantly due to expensive nature of commercial organic inputs and its access. Some, like Senthil from Nagarvalli, have embraced on-farm preparation of organic inputs, becoming more self-reliant in production. However, lacking access to niche organic consumer markets and network, these farmers are compelled to sell through regular mandis or conventional wholesale outlets. As a result, their organic produce is often treated the same as conventionally grown crops, fetching no or little economic incentive for their extra effort.

At best, these are farmers in transition seeking alternative channels. They attempt to gradually build direct relationships with consumers, participating in local fairs, or experimenting with social media outreach. However, these efforts require time, skills, and resources that may not always be available. Suitable ecosystem over time would gradually integrate these farmers in alternate systems and move towards viability. Currently, this space barely gets any attention, and this transition is often slow and fraught with practical challenges.

Key features of the farmers under this group include

- Often, these farmers operate outside any formal or informal organic networks like groups, collectives, etc., missing out on the benefits of shared learning and collective marketing.
- The absence of support structures intensifies their sense of isolation and grapple with a lack of recognition for their efforts. This sometimes leads to frustration, disillusionment, or even a return to conventional methods.

With the variety of design and model discussed above, a large number of farmers have built robust models of self-sufficiency or community-driven success. However, others remain caught between the ideals of organic farming and the realities of the conventional market. Their stories underscore the need for more accessible support systems, reliable input supply chains, and innovative marketing channels.

## 4.3 Attributes of Organic Farmers

The transition to organic agriculture goes beyond simple change in techniques to a holistic transformation often shaped by a range of distinct qualities and attitudes of the farmers. Understanding these qualities is essential to appreciate both the efforts and challenges of organic farming. Qualitative interaction with the organic farmers enabled us capture some of these attributes to an extent as described below.

### 4.3.1 Knowledge Exchange and Innovation

Organic farmers in Tamil Nadu demonstrate a strong willingness to experiment and diversify. Many actively cultivate knowledge networks rather than operating in isolation. Some serve as informal knowledge hubs, organizing trainings, exposure visits, and workshops for fellow farmers. Agro-ecology trainer farms, for instance, function as decentralized learning centers where farmers document, demonstrate, and refine agro-ecological practices. These farmers often act as nodal points within regional networks, extending their influence beyond their own farm boundaries.

Farmers actively seek out to insights sourced from YouTube channels and agricultural literature. They often innovate by blending traditional wisdom with recent technology and trends. The exchange of ideas is not limited to farming techniques but extends to marketing strategies and economic models, such as collective sales initiatives and agrotourism ventures.

### 4.3.2 Resilience and Openness to Change

Resilience is one of the key characteristics of the organic farmers that distinguishes them from the larger masses. Most of these farmers design their own resilience strategy to stay viable even after several setbacks and constantly evolve their approach to address the local conditions and market demands. In Tirupur, farmers who initially participated in government-regulated Uzhavar Sandhai evolved into an independent organic marketplace Sivan Organic Sandhai serving over 300 regular consumers. This shift reflects institutional adaptability in the face of structural constraints.

While farmers need to navigate the farm level challenges like soil rejuvenation, production risk, etc., during their transition to organic farming, they also need to carefully negotiate with the family members and address several complex social dynamics and relations in the society. Willingness among farmers to endure these short-term hardships and stay motivated through the period of transition become the critical attributes as described by several organic farmers.

Farmers in transitional "search for light" scenarios continue experimenting with organic production despite remaining entangled in conventional markets and facing systemic barriers such as weak dedicated market linkages. Their persistence under constraint reflects both ecological conviction and adaptive resilience.

### 4.3.3 Community Engagement and Collaboration

Organic farmers often realise the importance of collaboration, joining collectives, cooperatives, and farmer networks. Weekly organic markets in districts such as Dindigul and Tirupur reflect sustained collaborative efforts spanning several years. These groups allow for collective problem-solving, shared marketing efforts, and joint participation in events like local exhibitions and fairs. Such collaboration not only strengthens their economic position but also builds solidarity and a sense of shared purpose.

Furthermore, in weekly markets organised by TNIVK and its network partners, several other community engagements activities related to farming and traditional knowledge systems like pottery, folk arts, traditional cuisine competitions, etc. are organized. These initiatives create educational space for the consumers and offer a lively participation with community beyond a market.

### 4.3.4 Economic Pragmatism

While ecological health and consumer safety are cited as strong motivations, economic viability remains central. Most of the organic farmers balance ecological ideals with economic realities. Some farmers focus on value addition and direct-to-consumer marketing. Allied service farmers supplement income through seed saving and formulation production, strengthening both livelihood and ecosystem infrastructure. Even hobby and supplemental design farmers, though less market-driven, explore eco-tourism and diversified farm outputs. While committed to soil health and consumer safety, they remain pragmatic in navigating fluctuating market, meagre government support and other challenges.

### 4.3.5 Philosophical Commitment and Technology Adoption

For many farmers, organic farming reflects a philosophical orientation rooted in soil regeneration, self-reliance, and harmony with nature. For example, lifestyle-oriented farmers design highly resource-recycling farms emphasizing sustainability and long-term regeneration. Further, several farmers does not believe in organic certification approach and even against premium pricing of organic produce.

At the same time, these farmers demonstrate openness to technological adoption. Many integrate learnings from training and digital media into their practices and actively use online channels for marketing and consumer outreach. This blending of philosophical grounding with technological application characterizes the contemporary organic farmer in Tamil Nadu.

Across these operational models and farmer attributes, the shared pattern among farmers is their experimental and adaptative nature. These farmers do not passively adopt fixed prescriptions as they continuously refine practices and strategies in response to ecological feedback, economic realities, and community contexts. It is evident that production innovation and market innovation are evolving together. They blend traditional knowledge with modern tools, build peer networks for knowledge exchange, experiment with formulations and cropping systems, and create alternative market mechanisms when conventional systems fall short.

Going beyond passive agents of change, these farmers are actively shaping their own farming systems, prepared to meet both challenges and opportunities creatively. This adaptive, networked, and experimentation-driven character forms the foundation for the knowledge synthesis presented in the following section. The formulations documented ahead are therefore not isolated recipes, but expressions of a living system of farmer-led innovation.

## 5. Knowledge synthesis

The knowledge synthesis presented in this section builds on detailed field interactions with experienced agro-ecological farmers across Tamil Nadu and seeks to move beyond simple cataloguing of practices. The section begins by presenting the prevalence and distribution of various formulations across districts, providing a snapshot of practice diversity and adoption patterns. It then offers detailed documentation of practices under soil nutrient management and pest and disease management, describing their core ingredients, preparation processes, application parameters, and farmer-led innovations.

Further, the practices are contextualized with relevant peer-reviewed scientific literature to identify alignments, extensions, and research gaps. Rather than standardizing formulations into rigid prescriptions, this approach highlights the ecological roles of ingredients and the reasoning embedded in farmer experimentation. In doing so, it creates a bridge between experiential knowledge and scientific validation, enabling cross-learning, critical reflection, and future collaborative research within the organic farming ecosystem.

## 5.1 Diversity and distribution

The organic inputs prepared and used by the organic farmers are highly diverse across the districts in Tamil Nadu. Organic formulations are tailored to the needs of the farm and local resource availability by farmers based on their experience and knowledge. Local adaptation along with traditional wisdom and innovative experimentation among the farmers offers a great scope of mutual learning. Over thirty different organic formulations and practices ranging from centuries-old Panchagavya and Jeevamritam to specialized pest repellents, microbial solutions, seed treatments, and botanical extracts were shared by the farmers.

Table 3 and 4 capture the range of organic formulations adopted by farmers across the surveyed region with respect to soil nutrient management and pest/disease control respectively. The matrix form helps us to understand the prominence of different inputs in different districts.

***Table 3 Soil Nutrient management practices and its prevalence***

| Input | Cuddalore | Chengalpattu | Salem | Tiruppur | Tanjavur | Pudukottai | Dindigul | Total |
|---|---|---|---|---|---|---|---|---|
| Meenamilam (Fish Amino) | 4 | 2 | 1 | 2 | 3 | 0 | 6 | 18 |
| Jeevamritam / Amirdhakaraisal | 0 | 1 | 1 | 3 | 1 | 0 | 7 | 13 |
| Green Manuring | 2 | 1 | 2 | 1 | 2 | 2 | 2 | 12 |
| Panchagavya | 2 | 1 | 0 | 1 | 2 | 0 | 4 | 10 |
| Enriched Bioinput/Compost | 0 | 1 | 2 | 1 | 0 | 1 | 2 | 7 |
| EM1 and EM2 or LAB | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 5 |
| Pazha EM (Fruit Mix) | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 3 |
| Ghanajeevamrit | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 2 |
| Saani Paasi Karaisal | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 2 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Beejamritam (Seed Treatment) | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 2 |
| Waste Decomposer | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 2 |
| Cynobacteria / Algae Mix | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 2 |
| Micronutrient Karaisal | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 2 |
| Perungaya Karaisal | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 2 |
| Thayir Copper Karaisal | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| Rock Phosphate | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| Total number of formulation cited | 13 | 9 | 10 | 8 | 9 | 8 | 30 | 87 |
| Number of farmers interviewed | 7 | 4 | 6 | 8 | 4 | 5 | 15 | 49 |

***Table 4 Pest and Disease Management Practices and its prevalence***

| **Input** | **Cuddalore** | **Chengalpattu** | **Salem** | **Tiruppur** | **Tanjavur** | **Pudukottai** | **Dindigul** | **Total** |
|---|---|---|---|---|---|---|---|---|
| Poochiveratti / Illai mixes | 2 | 1 | 2 | 1 | 2 | 2 | 4 | 14 |
| Punnaku Karaisal (Oil Cake) | 1 | 0 | 1 | 1 | 1 | 2 | 1 | 7 |
| Moor Karaisal / Theimoor | 2 | 0 | 1 | 0 | 1 | 1 | 2 | 7 |
| Agnihastra (Herbal Repellent) | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 4 |
| Ennai Karaisal (Oil Mix) | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 4 |
| Karpura Karaisal (Camphor) | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 3 |
| 3G Karaisal (Garlic-Ginger-Chilli) | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 |
| Kadal Paasi Thiravam (Seaweed) | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 |
| Veppankottai Karaisal | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 2 |
| Kabodh / Pheromone traps | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 2 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Vella Velanmaram Pattai Karaisal | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 |
| Sticky Traps (Yellow/Blue/White) | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 |
| Vepa Karaisal (Neem Seed) | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| Vasumbu Karaisal | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| Total number of formulation cited | 6 | 1 | 8 | 4 | 5 | 7 | 23 | 54 |
| Number of farmers interviewed | 7 | 4 | 6 | 8 | 4 | 5 | 15 | |

To deep dive into the knowledge spectrum of the formulations and practices adopted by the experienced farmers interviewed under the study, the diversity and nuances of each of the formulations is discussed in the following sections.

## 5.2 Soil nutrient management practices

### 5.2.1 Green Manuring

Green manuring involves growing specific nitrogen-fixing and biomass-producing crops that are subsequently incorporated into the soil to enhance organic matter, soil structure, and nutrient availability. Green manuring was the most prevalent agro-ecological practice with 18 farmers (44% of sample) practicing it on a regular basis which in a way depicts its fundamental importance in organic farming systems. The technique serves as an affordable method of sustainable soil fertility management, providing nitrogen fixation, organic matter addition, and soil structure improvement.

*Core practice and diversity*

In most cases, nitrogen-fixing leguminous crops like sanapai and thakapoondu are grown for about 45-60 days before being ploughed into soil to enhance organic matter and soil fertility. This is often considered as the established traditional practice and observed across the districts. Alternatively, farmers grow a diverse range of 9-20 crops to be ploughed back into the soil. In this case, farmers often add 4 types of pulses, 4 types of oilseeds, 4 types of millets along with crops like sanapai, thakapoondu, avuri, etc. It was observed that multiple farmers in same districts use similar crop combinations, suggesting peer learning networks. Table 5 gives the list of application parameters from practice along with the same from literature.

***Table 5 Application and process parameters: Green manuring***

| Parameter | Range in practice | Range from literature |
|---|---|---|
| Batch size / Seed quantity | 8–25 kg seed per acre; mixed species (10–15 crops) in some farms | 15–25 kg seeds per acre |
| Duration | 18–21 days to 60 days growth before incorporation; | 45–60 days growth period |

| | | |
|---|---|---|
| Application method | Broadcast sowing and incorporation into soil | In-situ incorporation before main crop |
| Dosage / Volume per acre | 8–25 kg seed mix per acre | ~20 kg/acre |
| Timing / Frequency | Before maincrop, once yearly or during transition | Summer or winter green manuring |
| Crop Combinations | 1. Sanapai<br>2. Thakapoondu<br>3. Avuri<br>4. Horsegram or Tur<br>5. A mix of dicotyledon crops<br>6. A mix of 4-5 pulses, 4-5 oil seeds, 4-5 millets along with sanapai and thakapoondu | Sanapai or Thakapoondu |
| Cost | Variable by crop mix (About Rs.2000 on seeds) | Rs.2000/acre |

*Notable observations/innovations*

- Jayachandran (Chengalpattu) uses less prevalent crops like wild indigo, Jungle mat bean for green manuring. He particularly suggested wild indigo for areas where open grazing is problem as the cattle and goats don’t feed on this plant.
- Muniyan (Pudukottai) employs biodiversity maximization strategy with "15 crops including 4 pulses, 4 oilseeds, 4 millets, sanapai and thakapoodu". He believes this approach of multi-functional green manuring will provide a comprehensive soil health. He also suggests "3 rounds of green manuring during transition - 30 days, then 60 days and then 90 days" for a strategic intensification during organic conversion period
- Similar to Muniyan, Bharath Kumar & Siva Raman (Cuddalore) practice green manuring with about 15-20 crops (aggregated seed pack purchased from market) which contains pulses, oilseeds, traditional paddy, millets, etc. They practice green manuring to compensate for limited FYM availability.
- Prakash (Salem) indicated pest management benefits through cultivation of tur and horsegram intercropping with coconut plantation which he believes to have helped him control whitefly.
- John (Pudukottai) indicated that green manuring once a year has resulted in plenty of earthworm demonstrating the success of practice.
- Muniyan also adopt green leaf manuring as green manuring is prone to grazing. In such a scenario, he collects leaves like villari illai, aavaram illai, aanan, gliceridia, etc. and mulches it in the farm.
- Aravazhi indicated that at times when time available before sowing is limited, green manure crops are ploughed into soil in 18-20 days rather than completely skipping the green manuring practice.

These observations reveal green manuring as a key practice where farmers demonstrate sophisticated understanding of soil ecology, crop selection, timing, and integration with overall farm systems for the sustainable soil fertility management in Tamil Nadu's organic farming ecosystem.

*Scientific Literature*

Long-term experiments show that legume-based green manures fix atmospheric nitrogen, increase soil organic matter, improve soil structure and aggregation, stimulate microbial activity, enhance nutrient cycling, and can partially substitute mineral N, while also suppressing weeds and some pests.

Green manuring is one of the best-studied agro-ecological soil fertility practices. Recent syntheses show strong evidence that legume and mixed-species green manures improve soil physical, chemical and biological quality, including higher soil organic matter, better structure and aggregation, enhanced nutrient cycling, and more active and diverse microbial communities. Table 6 gives a broad overview of various scientifically documented functions of green manuring with corresponding references.

***Table 6 Supporting literature: Green manuring***

| Farmer observation / function | Key relevant findings from literature | References |
|---|---|---|
| Diverse mixtures (pulses, oilseeds, millets + classic green manure species) for "comprehensive soil health" | Different green manure species and rotations improve soil organic matter, nutrients, enzyme activity and microbial diversity; mixtures and multi-species rotations enhance multifunctionality and soil quality. | (Wang et al., 2025; Wang et al., 2024) |
| Repeated/intensive green manuring in transition years to accelerate soil restoration | Integrating green manuring with reduced fertilizer in Indian cereal systems improves soil organic C, available NPK, microbial activity and soil quality indices within a few seasons, with small or no yield penalties. | (Behera et al., 2025; Patil et al., 2025) |
| Substituting green manuring where FYM is scarce | Meta-analysis from India shows green manure is among the most effective regenerative practices for building soil organic carbon, next to FYM and biochar, especially over longer durations. | (Patil et al., 2025) |
| Timing: May–June, 45–60 days before main crop | Experiments with Sesbania and other legumes show that incorporating green manure at or near flowering (~40–60 days) maximizes biomass, N accumulation, and benefits to following crops. | (Behera et al., 2025; Lyu et al., 2024) |
| Earthworms and visible soil biological activity increase after annual green manuring | Green manures enhance soil organic matter and microbial diversity, and long-term organic/green manure use strengthens diazotroph and mycorrhizal networks and overall biological activity. | (Wang et al., 2025; Zhou et al., 2023) |
| Weed and some pest suppression (e.g., tur/horsegram in coconut, dense stands reducing weeds) | Green manures act as cover crops that improve soil quality and can suppress weeds and pests indirectly by enhancing soil health, crop vigor and ecological regulation. | (Wang et al., 2025; Lyu et al., 2024) |

### 5.2.2 Jeevamirtham and Amirdhakaraisal

Jeevamirtham is a liquid microbial culture prepared from cow dung, cow urine, jaggery, pulse flour, a fistful of healthy soil and water, fermented for 24-72 hours to activate beneficial soil microorganisms. Amirdhakaraisal is prepared with cow dung, cow urine and jaggery alone without pulse flour and soil inoculum, and used in similar context to jeevamirtham. Used by 17 farmers covered under the study, jeevamirtham represents the second most adopted practice and one of the commonly known and adopted soil fertility management practices in organic farming. The formulation functions as both a microbial inoculant and growth promoter, enhancing soil biology while providing readily available nutrients to plants.

#### *Core practice and diversity*

The core ingredients used for the preparation of amirdhakaraisal remains almost constant across the districts with cow dung, cow urine, country jaggery, pulse flour, and water, and an optional handful of soil from root zones of a healthy wild plant. The preparation involves mixing the components sequentially, followed by 24-72 hours of fermentation with daily stirring, creating approximately 200L of liquid microbial culture ready for field application. While the ingredients are mostly consistent, the frequency of application parameters show a large diversity from once per cropping season to once a week throughout the cropping season. Table 7 below gives the range and most common quantity of ingredients used in jeevamirtham and Table 8 provides other application parameters of the formulation.

***Table 7 Ingredients and their role: Jeevamirtham***

| Ingredient | Role / Function (farmer understanding) | Range in practice | Range from literature |
|---|---|---|---|
| Cow dung | Microbial base, organic matter | 10–20 kg | 10 kg |
| Cow urine (Komiyam) | Microbial activator | 5–20 L | 10 L |
| Country sugar / jaggery | Microbial energy source | 1–10 kg | 2 kg |
| Pulse flour | Nitrogen source for microbes | 1–2 kg | 2 kg |
| Water | Fermentation medium | ~200–250 L | 200 L |
| Soil (handful) | Local microbial inoculum | 1 handful | 1 handful |

***Table 8 Application and process parameters: Jeevamirtham***

| Parameter | Range in practice | Range from literature |
|---|---|---|
| Batch size | 200 L water base common | 200 L |
| Fermentation duration | 24 hrs to 7 days | 5-7 days |
| Stirring needs | 1–2 times/day | Stir twice daily |
| Application method | Fertigation through drip; soil drench | Soil drench and optionally foliar spray |

| | | |
|---|---|---|
| Dilution needs | Usually applied directly or applied through irrigation | Undiluted; 5-10% for spray |
| Dosage / Volume per acre | 200 L per acre; About 500 L in intensive systems | 3200 L per acre for high value crop and 400 – 1000 L per acre in cereals |
| Timing / Frequency | 7–10 days after sowing; once every 10–15 days | 7-20 DAS then once every 10-15 days |
| Shelf life | 3–7 days after fermentation | Within 7-10 days of preparation |

*Notable observations/innovations*

While the addition of handful of soil was a key variation observed across the state, several specific observations are listed below

- Muniyan (Pudukottai) avoids komiyam in jeevamirtham preparation to reduce the addition of salt content in his soil which already saline.
- Ajay (Dindigul) uses sand filter instead of screen filter for Jeevamirtham to prevent clogging issues during fertigation of jeevamirtham through drip irrigation system.
- Ajay (Dindigul) suggests addition of a fist of vasambu powder for enhanced microbial fermentation demonstrating an integration of traditional Siddha medicine principles.
- Periyasami (Dindigul) suggests addition of 1kg of ash for potash supplementation and pH correction
- Aravazhi (Cuddalore) combines traditional cow dung base with 1kg each of Azo, Pseudomonas, Phosphobacter for an enriched microbial content in jeevamirtham preparation.
- Sanmugam (Salem) specifically uses horsegram instead of generic pulse flour for an improved performance of jeevamirtham.
- Several farmers in Pudukottai use groundnut cake as a substitute to pulse flour due to the availability of oil cake in their locality as they believe it enhances the nutrient base for microbial growth.

These observations reveal that jeevamirtham as one of the most widely adopted practice where farmers actively experiment and adapt core formulations based on local conditions and available materials with the focus on soil microbiota. A significant number of farmers cited an intensive application of about 200L of amrithakaraisal per week through the cropping season for a yield comparable to chemical farms.

*Scientific literature*

The preparation protocol and ingredient ratios used by farmers closely resemble Jeevamrit formulations tested in recent agronomic and soil-microbiological studies, which also use cow dung, cow urine, jaggery, pulse flour and a small quantity of soil, fermented in ~200 L batches with daily stirring. Recent microbiological work shows that such cow-based liquid manures are dense, diverse microbial cultures dominated by plant-beneficial bacteria and fungi, supporting their use as low-cost microbial inoculants and biostimulants in organic farming systems.

Research protocols range from applications every 15 days as soil drench (Kaushal et al., 2024)to twice-weekly foliar and soil applications during critical crop stages (Mukherjee et al., 2025), indicating that frequency is often adapted to crop and context rather than standardized. The following table gives a broad overview of various scientifically documented functions of jeevamirtham with corresponding references.

***Table 9 Supporting literature: Jeevamirtham***

| Aspect | Key relevant findings from literature | References |
|---|---|---|
| Ingredients & preparation | Cow dung, cow urine, jaggery, pulse flour, soil, water; ~200 L batches, fermented, stirred daily | (P et al., 2022; Harish & Chaitra, 2024) |
| Microbial nature & mode of action | High-diversity fermentative microbial culture (Firmicutes, Proteobacteria, etc.), rich metabolites and proteins | (P et al., 2022; Saharan et al., 2023) |
| Soil biology & fertility effects | ↑ SOC, available NPK and micronutrients; ↑ microbial load, enzymes, water-holding capacity | (Saharan et al., 2023; Singh et al., 2024) |
| Crop growth & yield effects | Improved yield, quality and shelf life in marigold and strawberry; better economics vs. conventional | (Kaushal et al., 2024; Kumar et al., 2025) |
| Role in natural / ZBNF systems | Core ZBNF/natural farming input; biofertilizer and biopesticide role highlighted | (Kaur et al., 2020; Thakur et al., 2025) |

### 5.2.3 Panchagavyam

Panchagavyam is a traditional cattle-based five-ingredient preparation used by farmers across Tamil Nadu catering to multiple functions like growth promoters, immunity boosters, and disease preventers. Though it is often considered as an expensive input compared to other organic formulations, 9 farmers (22% of sample) covered under the study use the formulation. Interestingly, most of the farmers covered from Thanjavur used Panchagavyam but was notably absent among farmers covered under the study in the districts of Salem and Tiruppur.

*Core practice and diversity*

Often farmers signify Panchagavya as a culturally important formulation built on five cattle products which includes cow dung, cow urine, milk, curd, and ghee, enhanced with organic materials like bananas, coconut sap water, jaggery, sugarcane juice, etc. The consistent 21-day fermentation period across farmers indicates established traditional protocol in practice. Regional variations include coastal farmers incorporating coconut water and coconut milk, addition of groundnut cake for sustained protein release, and inclusion of rice water for enhanced carbohydrate content. Formulation can be stored for a period upto 1-year and applied at 1-3% concentrations depending on application frequency and crop requirements, using sprayer pumps.

While most of the farmers applied panchagavyam through foliar spray, a few farmers applied it through drip irrigation as well. A few used it for seed and sapling treatment to prevent soil borne diseases and better germination. The frequency of application ranged from weekly, fortnightly, monthly, to timeline-based applications. Table 10 below give the list of ingredients used along with their role and Table 11 below gives other application parameters like fermentation period, frequency, etc.

***Table 10 Ingredients and their role: Panchagavyam***

| Ingredient | Role / Function | Range in practice | Range from literature |
|---|---|---|---|
| Cow dung | Base microbial substrate | 5–10 kg | 5-7 kg |
| Cow urine | Microbial stimulant | 4–8 L | 3-10 L |
| Milk | Nutrient source | 3–6 L | 2-3 L |
| Curd | Lactic microbes | 2–4 L | 1-2 L |
| Ghee | Fermentation enhancer | ~1 L | 0.5-1 kg |
| OPTIONAL | | | |
| Banana | Sugar & microbial feed | ~12 fruits | 12 fruits |
| Country sugar / jaggery | Fermentation energy | ~1 kg | 0.5-3 kg |
| Coconut milk / water / toddy | Growth-promoting additives | 1–2 L | 1.5-3 L |
| Oil Cake | Energy source | 1Kg | 200 gm |

***Table 11 Application and process parameters: Panchagavyam***

| Parameter | Range in practice | Range from literature |
|---|---|---|
| Batch size | 5–10 kg dung base | 5-7 kg |
| Fermentation duration | 21–45 days | 2–3 days dung+ghee pre-incubation, ~15 days after urine addition, then remaining days after adding milk/curd/others. |
| Stirring needs | Daily stirring reported in several cases | Twice-daily stirring (morning and evening), sometimes “clockwise and anticlockwise,” |
| Application method | Foliar spray; drip irrigation; growth promoter | Foliar spraying, soil drenching, and seed treatment |
| Dilution needs | 100–350 ml/10 L water | 2-5% depending on the crop |
| Dosage / Volume per acre | One batch may cover ~3 acres; 8–10 tanks/acre | 2-3 acres per batch |
| Timing / Frequency | Flowering stage; Fortnightly | 2–4 sprays at key stages with 10–15 days intervals |
| Shelf life | 6 months to 1 year | Upto a few months |

*Notable observations/innovations*

- A few farmers substituted ghee with castor oil or oil cake due to higher cost of ghee and felt the formulation remains effective.
- Farmers are using a range of supplementary ingredients that supports fermentation which includes banana, coconut water, toddy, yeast, jaggery, groundnut oil cakes, etc.

*Scientific literature*

While panchagavyam is popular among most of the farmers, its usage is often limited due to cost factor. However, farmers are coming up with substitutional and supplementary ingredients aiding the adoption of the formulation.

Analytical and field studies show that fermented Panchagavya solutions supply N, P, K and trace elements and carry dense populations of plant growth-promoting microbes, explaining farmers' observations of enhanced growth, vigour and disease tolerance. Farmer-led additions of bananas, coconut water, toddy, yeast, groundnut cake and rice water are consistent with research showing that carbon- and protein-rich co-substrates enhance fermentation and the diversity of plant growth-promoting bacteria in Panchagavya-type formulations.

The commonly observed 1–3% foliar sprays and seed/sapling treatments in the study villages are in line with experimental protocols, where 3% Panchagavya sprays improved fodder yields and traditional formulations enhanced seed germination and early seedling growth. There is now clear, replicated field evidence of agronomic benefits of panchgavyam, but there is a need for long-term scientific documentation. Table 12 gives a broad overview of various scientifically documented functions of panchagavyam with corresponding reference

***Table 12 Supporting literature: Panchagavyam***

| Farmer observation / function | Key relevant findings from literature | References |
|---|---|---|
| Growth promotion (better vegetative growth, yield, quality) | Field experiments in India show foliar Panchagavya (4–20%) significantly increases plant height, branches, seed yield and benefit–cost ratio in black cumin and other crops, confirming its role as a growth-promoting bioformulation. | (Belagumpi et al., 2024; Ananthi & Parasuraman, 2020) |
| Enhanced "immunity" and disease prevention | Experimental work on Southern sunnhemp mosaic virus–infected sunnhemp shows that seed treatment and foliar spray with Panchagavya improve growth and reduce viral intensity, demonstrating induced resistance and disease suppression in plants. | (Vallimayil & Sekar, 2012) |
| Seed/seedling treatment for germination and vigour | A recent Indian study reports that chilli seeds treated with 1% Panchagavya have higher germination, longer roots and shoots, and greater vigour index than water-treated controls, supporting farmer practice of using it on seeds and saplings. | (Dudhal & Chitale, 2025) |
| Soil health and "soil conditioning" | Panchagavya is described as a soil conditioner improving soil fertility by supplying macro- and micronutrients, plant growth hormones, and dense microbial populations (bacteria, fungi, lactobacilli, | (Raju et al., 2022) |

| | | |
|---|---|---|
| | methanogens) that enhance nutrient cycling and plant immune response in Indian organic systems. | |
| Microbial bio-stimulant (foliar/soil applications) | A Bacillus strain (PG-8) isolated from fermented Panchagavya shows multiple plant growth-promoting traits (IAA, GA, phosphate solubilization, exopolysaccharide production, stress tolerance) and significantly enhances groundnut growth, highlighting Panchagavya as a microbial bio-stimulant reservoir. | (Gohil et al., 2022) |
| Multifunctional agro-ecological input in organic systems | Recent Indian reviews synthesize evidence that cow-based Panchagavya enhances vegetable crop productivity, soil microbial activity, nutrient uptake, and disease suppression, positioning it as a multifunctional input for sustainable, low-external-input agriculture in India. | (Behera et al., 2024; Singh et al., 2024) |

### 5.2.4 Meenamilam

Meenamilam or fish amino acid is a fermented fish-based liquid fertilizer often prepared using fish waste. With 17 farmers adopting this practice (41% of sample), it represents one of the most popular organic inputs used for soil nutrient management in organic farms. The formulation serves as the primary nitrogen source in organic farming systems, replacing chemical nitrogen fertilizers through biological protein breakdown. Most of the farmers indicated meenamilam as the most economical and easy to prepare formulation with immediate and visible improvement in the crop.

*Core practice and diversity*

Meenamilam is one of the most consistent formulations of organic farming in Tamil Nadu, built on the fundamental 1:1 ratio of fresh fish to country jaggery that remains remarkably standard across all practitioners. The preparation involves fermenting equal quantities of fish or fish waste (ranging from 1-500kg depending on farm scale) with organic jaggery in airtight containers for period of about 2 months. The fermentation process typically reduces the original volume by approximately 25%, yielding concentrated extracts that farmers dilute to 0.5-1% concentrations for field application. Table 13 below give the list of ingredients used along with their role and Table 14 below gives other application parameters like fermentation period, frequency, etc.

***Table 13 Ingredients and their role: Meenamilam***

| **Ingredient** | **Role / Function** | **Quantity – Range in practice** | **Quantity – Based on literature** |
|---|---|---|---|
| Fish waste | Amino acid & nitrogen source | 1-5 kg | 1:1 ratio |
| Country jaggery | Fermentation energy | 1-5 kg | 1:1 ratio |
| OPTIIONAL | | | |
| Coconut water, banana, etc. | Nutrient source | Not specified | No reference |
| Cow dung | Faster preparation | Replacing jaggery | No reference |

*Table 14 Application and process parameters: Meenamilam*

| Parameter | Range in practice | Based on literature |
|---|---|---|
| Batch size | 1 kg fish + 1 kg jaggery (small batch) to 20 kg + 20 kg or larger community batches | 1-5 kg |
| Fermentation duration | 48 – 60 days | ~21days |
| Stirring needs | Mostly closed fermentation without stirring but few farmers suggested occasional stirring. | Static anaerobic |
| Application method | Foliar spray; root zone application; fertigation | Foliar spray and soil drench |
| Dilution needs | 1 ml/L to 7 ml/L; 200–250 ml/10 L; 50–70 ml per 10 L tank | 0.5% (5ml/L) |
| Dosage / Volume per acre | ~3 L/acre concentrate; 8–10 spray tanks/acre | Not specified |
| Timing / Frequency | 15–20 days after sowing; flowering or growth stage; 1-2 times per season to once in 10 days (some farms) | Weekly spray after transplantation |
| Shelf life | Few months to up to 5 months mentioned | Upto 3 months |

### *Notable observations/innovations*

- A few farmers in coastal districts like Subbu from Chengalpattu prefer sea fish esp. sardines, over pond fish for higher zinc and silica content.
- A couple of farmers like Augustine and Jaiganesh in Dindigul has experimented by replacing jaggery with cow dung and cow urine for fermentation and realized impressive results.
- Another farmer Kuzhanthivel in Dindigul adds a small amount of saani paasi karaisal for speeding up the fermentation process.
- Jayachandran from Chengalpattu suggest addition of coconut water to make it 1:1:1 ratio of inputs to enhance fermentation, utilizes natural enzymes and growth hormones present in coconut water for improved biological activity.

These observations reveal meenamilam as the one of most farmer friendly formulation popular among agro-ecological farmers in Tamilnadu.

### *Scientific literature*

Use of fish waste-based fertilizers as liquid organic manures is increasingly highlighted in organic and circular agriculture, where fish-emulsions, fish hydrolysates and fermented fish liquids are produced from heads, viscera and frames to recycle marine nutrients to cropland and horticultural crops. The standard meenamilam recipe (1:1 fish waste : jaggery, sealed fermentation) is closely aligned with documented fish amino acid (FAA) and gunapaselam/gunapaselam-type formulations that likewise use equal proportions of fish waste and jaggery or molasses and short- to medium-term fermentation.

Farmer innovations such as choosing seawater fish for micronutrients, substituting jaggery with cow dung and urine, adding local microbial starters and incorporating coconut water—mirror mechanisms discussed in studies on cow-dung–based bioformulations, EM-inoculated fish-waste fertilizers and other fermented organic preparations, where diverse carbon sources and microbial consortia enhance fermentation, nutrient release and soil microbiome function. The available research provides a strong general foundation for meenamilam-type practices, but there is a need for comparative studies examining fish-based liquid manures in detail. Table 15 gives a broad overview of various scientifically documented functions of meenamilam with corresponding references.

***Table 15 Supporting literature: Meenamilam***

| Farmer observation / function | Key relevant findings from literature | References |
|---|---|---|
| Immediate and visible crop response (rapid greening, growth) | Fish amino acid (FAA) significantly increased shoot and root growth, biomass and photosynthetic pigments of green gram at low concentrations, indicating strong growth promotion. | (Manisha et al., 2024) |
| Primary nitrogen source via amino acids (replacement/partial replacement of chemical N) | Fish protein fertilizer replacing 45 kg compound fertilizer with 10–20 kg fish amino acid fertilizer increased bamboo shoot yield by 23–26%. | (Zhao et al., 2025) |
| Enhances overall crop yield and marketable produce | Fish-waste fermentation fertilizer increased fresh and dry weight of Brassica rapa by 132% and 60% and Capsicum annuum by 74% and 47% vs. unfertilized control; FAA foliar application produced the highest number of marketable okra fruits compared with conventional fertilizer. | (Liu et al., 2025; Taer et al., 2025) |
| Supports beneficial soil microbes and nutrient cycling | Organic/amino-acid based fertilizers and bio-organic fertilizers enrich functional microbial taxa involved in C, N, P and S cycling, enhance enzyme activities (urease, dehydrogenase, phosphatase), and improve ecosystem multifunctionality compared with sole mineral fertilization. | (Hu et al., 2024; Francioli et al., 2016) |
| Farmer innovations with microbial starters (e.g., cow-based inocula, local ferments) to "speed" fermentation | Bio-organic and microbial fertilizer studies show that adding selected microbial consortia (e.g., Bacillus, Rhizobium, Trichoderma) during fermentation of organic substrates accelerates decomposition, increases NPK availability and soil enzyme activity, and improves plant growth and yield. | (Liu et al., 2025; Liu et al., 2020) |

### 5.2.5 Enriched Bioinput/Compost

Enriched compost is an advanced composting techniques that integrate traditional organic matter with commercially available microbial inoculants like Azospirillum, Pseudomonas, and Trichoderma to create enhanced soil amendments with a range of beneficial microbial population. Used by 10 farmers (24% of sample), this practice indicates the openness of farmers towards both the traditional knowledge and modern soil science.

### *Core practice and diversity*

In general, enriched compost is a mixture of three components including a base manure, microbial inoculants, and nutrient supplements. The manure base is often a combination of cow dung, goat dung, and poultry waste totalling to 2-3 tonnes, to which oil cakes from neem seed, groundnut, coconut or castor, totalling to 50-100 Kg are added for nutrient supplement. To this nutrient supplemented manure, microbial enhancement is made by incorporating commercially available biofertilizers such as Azospirillum for nitrogen fixation, Pseudomonas for disease suppression, Trichoderma for root health, and Phosphobacter for phosphorus mobilization, typically at 1kg each inoculant. The formulation is well mixed and stored for 7-14 days with occasional turning of the mass for temperature and moisture control.

The usual cycle goes from a phase of initial heat generation followed by gradual cooling as organic matter stabilizes into dark and crumbly material. Different farmers emphasised on diversity of different inputs like variety of manure base, range of oil cake and mix of diverse and compatible microbial formulation. Table 16 below give the list of ingredients used along with their role and Table 17 below gives other application parameters like fermentation period, frequency, etc.

***Table 16 Ingredients and their role: Enriched compost***

| Ingredient | Role / Function | Range in practice | Literature based |
|---|---|---|---|
| Cow dung | Microbial source | ~2 tons | 100-400 kg per tonne |
| Goat Dung | High nitrogen source | 0-1 tonne | 0-200 kg per tonne |
| Poultry waste | High nitrogen and phosphorus | 0-1 tonne | 100-300 kg per tonne |
| Oil cakes | Nutrient enrichment | 100 kg total or ~7 kg each of 5 types | 50-100 kg per tonne |
| Biofertilizers | Disease suppression | ~1 kg each | 0.5-2 kg per tonne |
| Country sugar | Microbial feed | ~3 kg | 5-20 kg per tonne |
| Water | Moisture for curing | ~10 L | 50-65% moisture |

***Table 17 Application and process parameters: Enriched compost***

| Parameter | Range in practice | Literature based |
|---|---|---|
| Batch size | No limits, as per availability | 100kg - tonnes |
| Fermentation / Curing duration | 7–10 days curing | 40-50 days |
| Stirring needs | Mixing during preparation; periodic turning | Turning every 3-10 days |
| Application method | Basal soil application | Basal soil incorporation |
| Dilution needs | Not applicable | Not applicable |

| | | |
|---|---|---|
| Dosage / Volume per acre | 200 kg/acre to 3 tonnes/acre depending on system | 0.8–4 tonnes/acre |
| Timing / Frequency | Before sowing or land preparation | 1-2 time per year |
| Shelf life | Up to 1 year if shade dried and stored | 6-12 Months |

*Notable observations/innovations*

- Several farmers add more supplements like Ajay integrate liquid jeevamirtham at 200ml per tonne of base material to create hybrid systems, Prakash uses waste decomposer along with the microbial inoculant to speeden the process, and John adds humic acid to increase the organic content.
- Farmers like Subbu suggested specific 2:2:1 ratio of Cow dung, Goat dung, and Poultry waste to be used for effective results.
- Farmers take conscious effort to buy microbial innoculant from trusted and reliable sources as a large proportion of market stock is outdated.

These observations reveal enriched compost/bioinput as one of the most popular and successful formulation integrating traditional organic matter management with modern microbiology.

*Scientific literature*

There is robust scientific evidence from multiple crops, diverse agro-ecological regions, and long-term studies demonstrating that enriched composts fortified with biofertilizer consortia and nutrient supplements consistently enhance soil health, microbial activity, nutrient availability, crop yield, and disease suppression compared to raw manures or mineral fertilisers alone. These outcomes have been validated in multi-season field trials and across various soil types, highlighting the generalisability and reliability of the enriched compost approach.

Field studies show that composts enriched with microbial inoculants accelerate composting, improve humification, enhance nutrient conservation and phytohormone production as well. These findings support farmers' observations that adding waste decomposer, jeevamirtham, or humic acid can speed stabilization and improve compost quality, and that trusted inoculant quality is critical for consistent performance. Table 18 gives a list of selective references on scientifically documented functions of enriched compost.

***Table 18 Supporting literature: Enriched compost***

| Aspect of farmer practice | Relevance of the findings | References |
|---|---|---|
| Manure + oil cakes as base for enrichment | Composted animal manures plus organic supplements form high-quality carriers for beneficial microbes. | Ahmed et al., 2023; Das et al., 2017 |
| Addition of N fixers, P solubilizers, Trichoderma | Mixed N-fixers, P-solubilizers and Trichoderma in organics boost nutrient use efficiency, roots and yield. | Billah et al., 2020; N & Saeid, 2022 |

| | | |
|---|---|---|
| Faster, hotter composting with inoculants | Microbial consortia accelerate thermophilic phases and decomposition, yielding mature compost in shorter time. | Li et al., 2022; Das et al., 2015 |
| Use of Pseudomonas and Trichoderma for soil health | Pseudomonas– and Trichoderma-based bio-organic fertilizers enhance soil biological activity and suppress pathogens. | Tao et al., 2020; Huang et al., 2023 |
| Emphasis on quality/shelf life of inoculants | Effective biofertilizers require inoculants formulated for survival, compatibility and sufficient population density. | Ahmed et al., 2023; Zainudin et al., 2022 |
| Hybrid systems with jeevamirtham, humic acid, waste decomposer | Organic fertilizers enriched with humic acids and PGPR show additive benefits for yield and soil microbes. | Hussain et al., 2019; N & Saeid, 2022 |

### 5.2.6 Effective Microorganism (EM)

In general, Effective Microorganism (EM) preparations are specialised blend of microbial inoculant developed and used for a range of specific purposes like soil health amendment, wastewater treatment, composting, etc. EM was registered as a trademark during early 1980s by a Japanese scientist Professor Teruo Higa for his purposefully developed mixture of naturally occurring microorganisms including photosynthetically active bacteria, lactic acid bacteria and yeasts, for improving soil health and promoting plant growth. But at present, farmers perceive EM as a specialised microbial inoculant or concentrate which could be used as mother culture to prepare large volume of active microbial formulation that would enhance soil health and help crop production. Several formulations of EMs are being practiced by the farmers which includes milk and rice wash water-based LAB (Lactic Acid Bacillus) formulation, fruit based EM, or commercially available EM solutions.

*EM1 and EM2*

LAB formulation has a stage 1 mother culture referred as EM1 and an activated field application form called EM2. The EM1 is a rice-milk based mother culture preparation involving controlled fermentation of rice wash water and milk in specific ratio, followed by serum isolation to create beneficial microorganism concentrates to be stored and used for about a year. EM2 represents the activated field application form of EM1. This formulation is used by 5 farmers (10% of sample) of farmers covered under the study, for a range of purpose including seed treatment, plant protection, crop growth, etc.

EM1 and EM2 formulation had similar base materials across famers covered under the study but had significant variation in composition. EM1 is prepared with rice-milk fermentation with mixing of raw milk and rice wash water in ratios ranging from 1:1 to 1:6, followed by 7-15 days of controlled anaerobic fermentation and subsequent serum isolation to concentrate beneficial bacteria followed by bacterial preservation through 1:1 jaggery addition for extended culture viability. This formulation serves as a foundation for creating larger volumes of beneficial microbe applications through EM2. EM2 is prepared by activating EM1 mother culture through controlled dilution (0.5L EM1 per 100L water) with addition of jaggery (1kg per 100L) and 24-48 hours of stirring to achieve optimal microbial population for application in the farm. Table 1 gives the range of ingredients used and Table 2 gives other process parameters.

### *Pazha EM (Fruit Mix)*

Pazha EM is a local adaptation of Fermented Fruit Juice (FFJ) practice from Korean Natural farming methods. FFJ represents a globally recognized practice where fruits are fermented with sugar to extract growth-promoting enzymes, hormones, and beneficial microorganisms for agricultural application. The pazha EM formulation demonstrate remarkable consistency across independent practitioners surveyed across districts, utilizing the universal 1:1:1 ratio of papaya, pumpkin, and banana as primary carbohydrate sources for beneficial microorganism cultivation, enhanced with country sugar for fermentation support. The preparation involves smashing of fruits or cutting fruits into small pieces for controlled degradation rates and fermenting with country sugar for 2-3 weeks. With 3 farmers (5% of sample) covered under the study are using Pazha EM which demonstrates farmer adaptation to local resource availability, creating cost-effective alternatives to imported ingredients to the soil. Table 19 below give the list of ingredients used along with their role and Table 20 below gives other application parameters like fermentation period, frequency, etc.

***Table 19 Ingredients and their role: EM karaisal***

| **Ingredient** | **Role / Function** | **Quantity – Range in practice** | **Quantity – Literature based** |
|---|---|---|---|
| **EM1** | | | |
| Rice wash water | Microbial starter and base | ~5 L | 18-20 L |
| Milk | Lactic bacteria source | 2–3 L | 1-2 L |
| Sugarcane juice | Microbial food | ~4 L | 1 kg sugar/2 kg chopped fruit |
| **EM2** | | | |
| EM1 starter | Inoculum for EM2 | 0.5 L | 1 L |
| Country sugar | Fermentation substrate | ~1 kg | 1 Kg |
| Water | Expansion medium | 21-100 L | 18-20 L |
| **Optional** | | | |
| Cow dung | Additional microbial load | 0-100 kg | 1-10% (V/W) |
| Cow urine | Nutrient base | 0-15L | A few litres per batch |
| Pulse flour | Nitrogen source | 0-1Kg | 1-5% (W/W) |
| **Pazha EM** | | | |
| Papaya | Sugars, native fruit microbiota | 1 | 1-2 kg |
| Pumpkin | Carbon source, moisture | 1 | 1 kg |
| Banana | Sugars, yeasts | 1 | 250 gm |

| | | | |
|---|---|---|---|
| Jaggery | Primary fermentable sugar | 1 | 1:2 (sugar to total substrate) |
| Other fruits | Added substrates, diversity | 0-1 | - |
| Country Egg | N, lipids, micronutrients | 0-1 | 1 egg |
| Healthy soil | Microbial inoculum | 0-1 fist | |

***Table 20 Application and process parameters: EM Karaisal***

| **Parameter** | **Range in practice** | **Common in practice** |
|---|---|---|
| Batch size | EM1: 5-20L; EM2: 100–200 L | 20-50 L |
| Fermentation duration | EM1: 21 days<br>EM2: 4–7 days<br>Fruit EM: 40 days | EM1 ~ 7-15 days, EM2 ~4–7 days |
| Stirring needs | EM1: 7 days anaerobic, 4 days aerobic and 10 days anaerobic<br>Fruit EM: 7 Aerobic and 30 days anaerobic | No stirring but regular opening of lid to vent gas |
| Application method | Soil drench; spray; mixed with dung or compost; | Soil drench, foliar spray and integration with mulch and compost |
| Dilution needs | Strong dilution e.g., 1 ml/L for LAB; EM2 diluted further in water) | 0.1-1% for spray |
| Dosage / Volume per acre | ~200 L EM2 per acre<br>Fruit EM: 1-2 L per acre | 1-1.2 L/acre |
| Timing / Frequency | Before sowing or periodic application | After germination, weekly |
| Shelf life | EM1: Upto 1 year<br>EM2: Immediate use only<br>Fruit EM: Upto 4 months | Weeks to several months |

### *Notable observations*

- EM or LAB preparation appeared to be moderately sophisticated process compared to Pazha EM. EM1/EM2 are usually adopted by farmers through close networks, guidance from trusted sources, or person experiments.
- A few farmers adopt aerobic fermentation during the initial phase followed by anaerobic fermentation suggesting the process help in enriching a range of beneficial microorganisms.
- A range of supplementary ingredients like sugarcane juice, egg protein, flour, etc. are experimented and used by farmers different EM formulations.

### *Scientific literature*

EM practices documented from farmer innovation align closely with the directions indicated by contemporary microbiome-based sustainable agriculture research. Studies highlight that microbial consortia are most effective when tailored to local conditions and carriers, and when integrated with organic amendments like what farmers achieve through rice-wash water, milk, jaggery, fruit mixtures, cow dung/urine and healthy soil as inocula and substrates.

Studies on soil-microbiome and bioformulation indicates that nurturing diverse, functionally complementary microbial consortia is central to agroecological transition, soil remediation and resilience under climate and input pressures. Table 21 gives a list of selective references on scientifically documented functions of EM karaisal.

***Table 21 Supporting literature: EM karaisal***

| Farmer observation / function | Key relevant findings from literature | References |
|---|---|---|
| EM1/EM2 improve soil health and soil biological activity | Microbial fertilizers and bio-inoculants enhance soil microbial diversity, enzymatic activity, organic matter and nutrient cycling, restoring degraded soils and supporting sustainable productivity. | (Wang et al., 2024; Gupta et al., 2022) |
| EM1/EM2 enhance crop growth and yield | EM-type microbial formulations across cereals, pulses, oilseeds and vegetables increase root/shoot growth, biomass, chlorophyll, nutrient content and yield, and improve stress tolerance. | (Naik et al., 2020; Koskey et al., 2021) |
| EM1/EM2 as seed treatment and plant establishment aid | Microbial bioformulations and PGPM/PGPR consortia used as seed or root inoculants improve germination, root architecture, nutrient uptake and early vigor, acting as biostimulants. | (Khan et al., 2023; Backer et al., 2018) |
| EM1/EM2 contribute to plant protection / pest and disease suppression | Plant growth-promoting microbes and microbial fertilizers induce systemic resistance and suppress pathogens via competition, antibiotics and secondary metabolites, reducing need for chemical pesticides. | (Koskey et al., 2021; Wang et al., 2024) |
| Mixed substrates and staged aerobic→anaerobic fermentation yield diverse LAB-dominated communities | Microbial consortia with lactic acid bacteria and other PGPMs are central to effective EM-type products; fermented residue preparations are dominated by Lactobacillus and other Firmicutes/ Proteobacteria. | (Zoumman et al., 2025; Naik et al., 2020) |
| EM1/EM2 as low-cost, on-farm microbial fertilizer reducing agro-chemical dependence | Reviews on bio-inocula and EM/PGPM stress their role as inexpensive, eco-friendly tools for smallholders to cut synthetic fertilizer and pesticide use while maintaining yields. | (Koskey et al., 2021; Qadir et al., 2024) |
| Pazha EM / fruit-based EM improve plant growth via fruit-derived metabolites and LAB | Fermented plant/organic substrates used as carriers for microbial consortia act as biostimulants; PGPM consortia on organic residues enhance root traits and biomass in tomato and other crops. | (Zoumman et al., 2025; Santoyo et al., 2021) |
| Pazha EM as source of microbial enzymes and “growth-promoting substances” | Microbial fertilizers and PGPR consortia produce phytohormones, enzymes and other metabolites that stimulate plant growth, nutrient uptake and stress tolerance, fitting farmer reports of growth-promotion from fermented fruit mixes. | (Wang et al., 2024; Backer et al., 2018) |

| | | |
|---|---|---|
| Inclusion of healthy soil, cow dung/urine, pulse flour, egg to broaden consortia | Microbial consortia assembled from diverse organic substrates and native soils outperform single strains for nutrient cycling, disease suppression and soil remediation, and are a core strategy in bio-inoculum design. | (Santoyo et al., 2021; Samantaray et al., 2024) |
| Short-term activated cultures (EM2, Pazha EM) require rapid use and are microbiologically dense | Bioformulation reviews stress the importance of carrier choice, fermentation conditions and shelf-life; actively fermented mixed cultures reach high cell densities but viability declines without suitable carriers or stabilization, so fresh use is recommended. | (Khan et al., 2023; Naik et al., 2020) |

### 5.2.7 Ghanajeevamrit

Ghanajeevamritam is a solid/semi-solid enriched organic manure that serves as a slow-release soil fertility enhancer. It offers a high-potency organic matter source acting as a carrier for beneficial microorganisms. It delivers sustained, slow-release nutrition over extended periods ensuring effective microbial activation for an improved soil health. Its stable nature allows advance preparation for later application by the farmers with limited access to cow dung. Adopted by 4 farmers (10% of sample), this practice could be considered as solid inoculant of beneficial microbes introduced in the soil.

*Core practice and diversity*

The formulation is prepared by adding 10L of jeevamirtham to about 200kg of cow dung and shadow dried for 21 days. Some farmers supplement the process by adding ingredients like jaggery and pulses flour. Farmers have also suggested enriching ghanjeevamirtam with addition of microbial fertilisers like Azospirillum, Pseudomonas, etc. Another farmer prefers goat dung over cow dung due higher nitrogen content in the manure. Table 22 below give the list of ingredients used along with their role and Table 23 below gives other application parameters like fermentation period, frequency, etc.

***Table 22 Ingredients and their role: Ghanajeevamirtham***

| **Ingredient** | **Role / Function** | **Range in practice** |
|---|---|---|
| Cow dung | Base solid microbial carrier | 100-200 kg |
| Liquid Jeevamirtham | Microbial enhancer | 10 L |
| Country Sugar/Jaggery | Energy source | 0-1 kg |
| Pulse flour (dicot varieties preferred) | Nitrogen medium | |
| OPTIONAL | | |
| Ghee | Microbial activation | ~1 L |
| Sour curd | Lactobacilli source | 7 L |
| Raw milk | Nutrient source | 7 L |
| Biofertilizers (Azo, Pseudomonas, Phosphobacteria) | Microbial enrichment | 1 kg each |

*Table 23 Application and process parameters: Ghanajeevamirtham*

| Parameter | Range in practice |
|---|---|
| Batch size | 100–200 kg cow dung base |
| Fermentation duration | ~48 hrs; sometimes prepared through multi-stage process up to 21 days |
| Stirring needs | Mixing during preparation; limited or no repeated stirring reported |
| Application method | Soil application/broadcasting; added to field as solid manure |
| Dilution needs (if any) | Not applicable |
| Dosage / Volume per acre | 100-200 kg per acre |
| Timing / Frequency | Basal application during land preparation |
| Shelf life | Shadow drying and used upto 6 months |

### *Notable observations*

- Jeyalekshmi's advanced technique involves elaborate multi-stage processing with ghee-massaged cow dung, three-day sour curd, and raw milk components requiring 21 days of controlled fermentation with directional stirring, representing the most culturally and technically sophisticated approach documented.
- Processing requires careful moisture management to achieve proper "crumbly texture" without excessive wetness, typically accomplished through shadow drying rather than direct sun exposure to preserve beneficial microorganisms. The final product provides concentrated soil amendment capable of 3-6 month storage while delivering sustained nutrition and microbial enhancement, applied at rates of 100-200kg per acre during land preparation phases, demonstrating evolution from basic cow dung application toward scientifically enhanced organic matter management systems.
- Focus on achieving proper "puttu-like consistency" and "crumbling texture" shows sophisticated understanding of moisture management for optimal microbial activity and storage stability.

### *Scientific literature*

Direct scientific literature and documentation on ghanajeevamirtham are limited and growing. Several studies especially from India, have shown that application of Ghanajeevamritam act a solid microbial inoculant and a slow-release organic manure. Practices around multi-stage fermentation, shade drying, and base application at land preparation implements principles of biodiversity, building soil carbon, and reduced external inputs in locally adapted ways. Finer farmer innovations like exact fermentation durations, substrate combinations, application timings, interactions with specific crops or stress conditions, etc. are often ahead of the literature which needs detailed scientific studies and documentation. Table 24 gives a list of selective references on scientifically documented functions related to ghanajeevamirtham.

*Table 24 Supporting literature: Ghanajeevamirtham*

| Farmer observation / function | Key relevant findings from literature | References |
|---|---|---|
| High-potency organic input where FYM is scarce; slow-release nutrients | FYM + GhanaJeewamrita gives higher cowpea yield and soil biology than FYM alone; Ghana Jeevamrit carries NPK as a cow-manurial input in broccoli INM. | (Sharma et al., 2024; Shraddha et al., 2023) |
| Solid microbial inoculant for soil | Jeevamrit + Ghanjeevamrit raises bacteria, fungi, actinomycetes in rice–wheat vs FYM/NPK. | Darjee et al., 2024 |
| Fermented cow-based inputs "activate" soil life | Natural-input treatments (Jeevamrit, Ghanjeevamrit, Beejamrit) show higher dehydrogenase, β-glucosidase, urease, microbial biomass and populations than inorganic or FYM alone. | Darjee et al., 2024 |
| Shade-dried solid, applied at land preparation | Ghana Jeevamrit used as solid natural input within INM in rice–mustard–green gram, improving soil quality index. | Sarkar et al., 2024 |

### 5.2.8 Saani Paasi Karaisal

A specialized preparation involving cultivation and harvesting of blue-green algae (cyanobacteria) from controlled water environments, representing one the advanced practice in organic farming. Used by only 3 farmers (7% of sample), this specialized technique requires deep understanding of photosynthetic microorganism and cultivation methods. The formulation serves as a method of strengthening the nitrogen source in the soil by utilizing the free-living algae's natural ability to fix nitrogen and produce growth-promoting compounds for crop production.

*Core practice and diversity*

The cultivation process requires 10L water in wide vessels combined with 1kg fresh cow dung from a lactating cow, exposed to direct sunlight for 7 days while preventing rain contamination to achieve optimal algae growth conditions. The initial isolation process involves visual identification and manual collection of green algae biomass. Once the green algae is isolated, the biomass is used as inoculant and cultivated with coconut water (1L) and jaggery (50g) in about 200L water for 7-15 days exposed in sunlight. The entire content is either mixed with other organic inputs like jeevamritam, etc., or applied directly to the farm. Table 25 below give the list of ingredients used along with their role and Table 26 below gives other application parameters like fermentation period, frequency, etc.

*Table 25 Ingredients and their role: Saani paasi karaisal*

| Ingredient | Purpose | Range in practice | Range in literature |
|---|---|---|---|
| Mother culture | | | |
| Fresh lactating cow dung | Substrate with High-quality nutrients for algae growth | 1-5 kg | Not specified |
| Wide vessel | Maximum surface area for photosynthesis | | 5–30 cm water depth |
| Water Volume | Isolation of cyanobacteria | 10L standard | 250ml – 10L |
| Light Exposure | Photosynthetic activation | 7 days direct sunlight | 3–10 days |
| Other aspects | Protected from rain | Prevents contamination and dilution | Open systems are vulnerable contamination |
| Growth culture | | | |
| Tender coconut | Nutrient enrichment | 1 Litre | Not documented |
| Jaggery | Sugar supplement | 1 Kg | Not documented |

*Table 26 Application and process parameters: Saani paasi karaisal*

| Parameter | Range in practice | In literature |
|---|---|---|
| Batch size | 10 L water + dung culture, expanded to 200 L barrel | Lab "mother cultures" 0.25–10 L |
| Fermentation duration | 7 days sunlight culture + 7–15 days fermentation | 3–7 days for starter cultures<br>5–15 days for batch mass cultivation |
| Stirring needs | Daily stirring until froth appears | Frequent mixing is recommended to avoid settling and enhance gas exchange |
| Application method | Mixed with other organic inputs or irrigation water | Soil drench, soil amendment, or fertigation are common; often combined with other organic input |
| Dilution needs (if any) | 1:20L water | 1:10 – 1:50 dilution |
| Dosage / Volume per acre | ~1 L mother culture added to other inputs | Not specified |
| Timing / Frequency | Added during regular input applications | Pre-sowing and 1-3 times during crop growth |
| Shelf life | Continuous replication | A few weeks |

### Notable observations

- While one of farmers prepared the formulation from the scratch, other farmers purchased mother culture from a farmer called Loganathan in Namakkal and continued to store and replicate for seed culture.
- The formulation involves relatively advanced understanding of the practice with precise environmental management of water, nutrients, and light exposure to harvest photosynthetic microorganisms.
- While most of the organic formulation used for nutrient management focus on bacterial populations, key feature of saani paasi karaisal is its exclusive focus on harvesting cynobacteria for its nitrogen fixation function.

- Often this formulation is used as an enhancer to other organic formulation or catalyst to speed up the preparation of formulations like meenamilam, jeevamritam, etc.

*Scientific literature*

Cyanobacterial cultivation techniques like Saani Paasi Karaisal represent a promising sustainable agricultural practice. While there are no documented studies that isolate and characterize cyanobacterial strains *originating specifically from cow dung*, several experiments demonstrate that cow manure, dairy industry wastewater and cattle-waste effluents are effective, low-cost media for cyanobacterial cultivation and biomass production. This aligns with farmers' use of fresh cow dung slurry as the base medium for enriching and propagating blue-green algae in Saani Paasi Karaisal.

Though cyanobacteria are not *taxonomically isolated directly from fresh cattle dung* as the primary habitat, several scientific studies use cow dung or cattle manure (solid or liquid) explicitly as the growth medium or nutrient source for cyanobacterial cultivation, which is very close to what farmers are doing with Saani Paasi Karaisal. Further, substantial scientific literature is available particularly from Indian research on establishing the diversity of nitrogen-fixing *Nostoc* and *Anabaena* in paddy soils and their contribution (≈25–30 kg N $ha^{-1}$) to rice systems, providing a regional scientific backdrop for farmer innovations like Saani Paasi Karaisal.

***Table 27 Supporting literature: Saani paasi karaisal***

| **Farmer observation / function** | **Key relevant findings from literature** | **References** |
|---|---|---|
| Manure-based media for sustainable biomass production of cyanobacteria | Cow manure and other livestock wastes efficiently support cyanobacterial growth while removing nutrients; the resulting biomass, when co-digested with cattle dung. | (Álvarez et al., 2020; Markou & Georgakakis, 2011) |
| Strengthens nitrogen source in soil via cyanobacterial biomass | Heterocystous cyanobacteria (*Anabaena*, *Nostoc*) are major N-fixing biomass in rice and other soils, contributing ~20–30 kg N $ha^{-1}$ and significantly increase growth and yield | (Mahato & Sahu, 2017; Sahu et al., 2013; Hakkoum et al., 2025) |
| Produces growth-promoting compounds beyond nitrogen (acts like a biostimulant) | Cyanobacteria produce phytohormones (auxin, gibberellins), vitamins, amino acids and other secondary metabolites that stimulate root growth, biomass accumulation, stress tolerance and disease resistance | (Lorenzi & Chia, 2024; Kollmen & Strieth, 2022) |
| Improves soil structure, porosity and water-holding capacity | Cyanobacteria form soil surface consortia/biological soil crusts, secreting extracellular polymers that bind particles, improve aggregation, increase water retention and stabilize the soil surface | (Ammar et al., 2022; Chittora et al., 2020) |

| | | |
|---|---|---|
| Acts as a catalyst/enhancer when mixed with other organic formulations | Cyanobacterial biofertilizers integrate well with organic amendments | (Bibi et al., 2024; Hakkoum et al., 2025) |

### 5.2.9 Beejamritam

Beejamirtham is a traditional seed treatment preparation combining cow dung, cow urine, jaggery, and beneficial microorganisms to enhance seed viability and protect against diseases during germination. While a range of seed treatment was observed among the famers covered under the study, only 3 farmers (6% of sample) used beejamirtham formulation which is a basic form of organic seed conditioning focused on preventive crop healthcare during the seed stage. The formulation provides seed protection, disease prevention, and early nutrition for seedlings through beneficial microbial colonization and organic nutrient availability.

*Core practice and diversity*

Beejamritam is prepared by mixing cow dung (10kg), cow urine (5L), 150gm of limestone in 20L water with a handful of soil from root zones to introduce local beneficial microorganisms for seed conditioning and protection. The preparation is stored in shade for 12-24 hours before coating the seeds with the formulation and air dry for sowing. Table 28 below give the list of ingredients used along with their role and Table 29 below gives other application parameters like fermentation period, frequency, etc.

***Table 28 Ingredients and their role: Beejamirtham***

| Ingredient | Role / Function | Range in practice | Range in literature |
|---|---|---|---|
| Cow dung | Microbial coating | ~10 kg | 0.5 – 15 kg |
| Cow urine | Antifungal / microbial medium | ~5 L | 0.5 – 12.5 L |
| Lime | Protective treatment | 150gm | 50-250 gm |
| Water | Base medium | 20 L | 1-50 L |
| Healthy soil | Microbial inoculum | Handful | 0.25 – 1 kg |

***Table 29 Application and process parameters: Beejamirtham***

| Parameter | Range in practice | Range in Literature |
|---|---|---|
| Batch size | 10 kg dung, 5 L gomutram, lime, handful of soil (varies) | Small scale: 1-2 L<br>Field scale: 20-50 L |
| Fermentation duration | 12-24 hours | 24 hours common<br>4-5 days for optimum results |
| Stirring needs | Mixed before use | Mixed before application, intermittent mixing |
| Application method | Seed coating or soaking; nursery root dip | 4-12 hours of dipping or priming |
| Dilution needs (if any) | Usually used as prepared | Undiluted |
| Dosage / Volume per acre | 20L for 100kg seeds (Depend on crop) | ~20 L for seeds to be used per acre |

| | | |
|---|---|---|
| Timing / Frequency | Before sowing or transplantation | Before sowing or transplantation |
| Shelf life | Immediate use | Upto five days |

### *Notable observations*

- Some practitioners like Arvindan integrate commercial microbials such as Pseudomonas to enhance disease suppression capabilities, while others maintain purely traditional approaches using only farm-derived materials for complete self-sufficiency.
- Some farmers indicate the difficulty in buying indigenous seed and often depends on market for their seed. The market seeds are pre-treated with chemicals and hence they are left with limited choice but to avoid treatment with beejamritham.

### *Scientific literature*

Beejamritam's effects on germination, early vigor, and preventive "seed health care" are strongly and increasingly supported by microbiological and pot/plot studies. Many scientific studies from India validate most of the farmer-reported functions.

Farmer innovations such as adding commercial Pseudomonas cultures are consistent with global trends in microbial seed coating/biopriming, which seek to enhance disease suppression and stress tolerance by combining microbial strains and organic carriers. Constraints around chemically pre-treated market seed are also echoed in the seed-treatment literature, which stresses the need to integrate biological treatments without compromising seed viability or regulatory requirements. Table 30 gives a list of selective literature related to beejamirtham.

***Table 30 Supporting literature: Beejamirtham***

| Farmer observation / function | Key supporting evidence | References |
|---|---|---|
| Better germination and seedling vigour | Beejamrit seed treatment improved germination, seedling survival and shoot length in French bean compared with control. | (Mukherjee et al., 2022) |
| Early nutrition and biostimulant effect | Beejamrit contained abundant free-living N-fixers, phosphate-solubilizing bacteria and substantial indolic compounds (including IAA), indicating biostimulant potential. | (Mukherjee et al., 2022; Singh et al., 2023) |
| Preventive seed / soil disease protection | Beejamrit and related cow-dung–based supplements carried diverse beneficial microbes (N-fixers, PSB, high IAA), supporting roles in nutrient cycling and plant health. | (Singh et al., 2023; Bargaz et al., 2018) |
| Short fermentation and fresh use | Shelf-life study showed Beejamrutham microbial populations decline with storage; immediate use after preparation gives maximum benefit. | (Sudheer et al., 2024) |
| Compatible with broader microbial seed-treatment / PGPR paradigm | Reviews on bacterial plant biostimulants and PGPR-based biostimulants show that PGPR consortia used as seed/soil inoculants enhance | (Hamid et al., 2021; Sun et al., 2024) |

| | | |
|---|---|---|
| | germination, growth, nutrient uptake and stress tolerance. | |

### 5.2.10 Perungaya Karaisal

Perunaga karaisal (asafoetida solution) is a formulation based on asafoetida which is traditionally used in agriculture for its pest-repellent properties and often explored for its potential to promote plant growth. Asafoetida demonstrates a broad-spectrum disease suppression through antimicrobial, antifungal, and antiparasitic activities with evidence spanning from plant, animal, and human disease. Asafoetida is alsorecognized for its insecticidal, larvicidal, and insect repellent activities, making it a valuable botanical alternative to synthetic pesticides. Its essential oils and extracts have been shown to deter a range of pests, and it is considered safer for the environment and non-target organisms compared to chemical pesticides.

*Core practice and diversity*

Used by 3 farmers (7% of sample), this practice shows a geographic concentration in Dindigul district with no practice reported by farmers studied in other districts, making it a relatively exclusive practice of the region. Considered as a common traditional practice in Dindigul district, asafoetida is usually covered in a cloth or gunny bag and placed in irrigation channels for a continuous passive dispersion along with irrigated water in the soil. However, some farmers prefer direct spraying onto the plant especially during the flowering stage. Table 31 below give the list of ingredients used along with their role and Table 32 below gives other application parameters like fermentation period, frequency, etc.

***Table 31 Ingredients and their role: Perungaya karaisal***

| **Ingredient** | **Role / Function** | **Range in practice** | **Range in literature** |
|---|---|---|---|
| Perungayam (Asafoetida) | Pest repellent; flowering support (as observed by farmers) | 50 g | No direct report 0.124-1g/L water in larvicidal tests |
| Turmeric | Disease suppression | 50 g | No direct report, 5g/L (one report of field use with 5:1 baking soda) |
| Oilcake (Punnaku) | Nutrient carrier (drench variant) | 7.5 kg | No direct report, a few grams per kg soil |
| Water | Carrier medium | 200 L | No direct report |
| Optional | | | |
| Sour Buttermilk | Carrier medium, probiotics | 10L | No direct report |

***Table 32 Application and process parameters: Perungaya karaisal***

| Parameter | Range in practice | Range in literature |
|---|---|---|
| Batch size | 200 L preparations | No direct report |
| Fermentation duration | Immediate use or ~4 days fermentation | |

| | | |
|---|---|---|
| Stirring needs | Daily mixing | |
| Application method | Water channel placement or foliar spray | |
| Dilution needs (if any) | Directly applied | |
| Dosage / Volume per acre | 50gm per acre | |
| Timing / Frequency | Used during flowering stage or for pest management | |
| Shelf life | Short-term; fresh use preferred | |

*Notable observations*

- Farmers report immediate and visible impact in the field while using asofoetida based formulations.
- Though farmers indicate the role of formulation in inducing plant growth, there is limited documented evidence that asafoetida acts as a growth promoter, instead the impact of pest and disease control esp. during flowering period is likely to cause indirect and positive impact on crop growth and yield.

*Scientific Literature*

The available literature strongly supports asafoetida as a bioactive botanical for pest and disease management, but specific evidence on *Perunaga karaisal* as a field practice remains almost entirely farmer-led and innovative. Evidence on asafoetida's antimicrobial and insecticidal/repellent properties are mostly data from laboratory or non-crop systems rather than field trials.

Pharmacological and phytochemical reviews show that asafoetida oleo-gum resin contains resins, gums and essential oils with strong antimicrobial, antifungal, antiviral and antiparasitic activities across diverse pathogens, mediated by sulfur-rich volatiles and phenolics. However, robust crop-level evidence for direct plant growth promotion by asafoetida is limited and any yield benefit could also be an indirect effect of reduced pest and disease pressure which needs to be studied in detail.

***Table 33 Supporting literature: Perungaya karaisal***

| Farmer observation / function | Key relevant findings from literature | References |
|---|---|---|
| Asafoetida suppresses plant diseases (soil/foliar) | Asafoetida oleo-gum-resin shows broad antimicrobial and antifungal activity, supporting use for general disease suppression. | (Iranshahy & Iranshahi, 2011) |
| Asafoetida repels and kills insect pests | Asafoetida essential oil is strongly insecticidal and repellent to major pests (aphids, storage and field insects), acting as a natural biocide. | (Hamidian et al., 2024; Koorki et al., 2022) |
| Asafoetida in irrigation/drench affects mobile or soil-associated pests | Asafoetida essential oils and extracts show potent toxicity to aquatic and soft-bodied insects (e.g., mosquitoes, caterpillars), indicating efficacy when dispersed in water. | (Hamidian et al., 2024; Pavela et al., 2020) |

| | | |
|---|---|---|
| Turmeric in drench adds disease protection | Turmeric (Curcuma longa) essential oils are documented botanical insecticides/repellents, supporting a protective role in mixed plant-based formulations. | (Ngegba et al., 2022) |
| Sour buttermilk as carrier and microbial component | Agroecological and organic pest-management frameworks highlight combining biological agents and botanicals to support beneficial microbiomes and disease suppression. | (Belmain et al., 2022; Brzozowski & Mazourek, 2018) |
| Perceived plant growth/yield increase after asafoetida use | Reviews report strong antimicrobial and insecticidal actions of asafoetida but little direct evidence for hormone-like growth promotion; yield gains are mainly via pest/disease control. | (Hamidian et al., 2024; Iranshahy & Iranshahi, 2011) |

### 5.2.11 Other Seed Treatments

A diverse range of seed treatments methods are practiced for seed conditioning like panchagavya soaking, microbial treatments, herbal mixtures, and rainwater applications. About 9 farmers (17% of sample) covered under the study were using seed treatment practice other than beejamirtham. These practices serve multiple purposes including seed viability testing, disease prevention, growth enhancement, and microbial inoculation to support germination. Table 34 below gives the list of various seed treatment practices adopted by the farmers.

***Table 34 Seed treatment formulations***

| Treatment Method | Number of farmers | Formulation | Soaking Duration | Purpose |
|---|---|---|---|---|
| Microbial treatment | 3 | Pseudomonas, Trichoderma, Azospirillum, etc. | Crop-dependent | Disease suppression |
| LAB (Lactic Acid Bacillus) | 1 | Raw milk + rice wash water (6:1 ratio), 3-day fermentation, serum isolated + 1:1 jaggery | 1ml/1L water for spraying | Microbial seed treatment |
| Herbal mixture | 1 | Vasambu, neem, nochi, vada milagai mixture | Not specified | Pest prevention |
| Panchagavya soaking | 1 | 350ml/1L water | Crop-dependent | Nutrient supplement |
| Rain water soaking | 1 | Natural rain water | Crop-dependent | Natural conditioning |
| Uppu karaisal (salt solution) | 1 | For paddy | Not specified | Seed viability testing |
| Ash coating | 1 | Ash from dried cow dung burning | For storage | Seed preservation |

### 5.2.12 Waste Decomposer

Waste decomposer is a formulation containing specific microbial consortiums designed to rapidly break down organic materials and speed up the composting process. Though adopted by farmers from two districts, the minimal awareness and usage indicate limited market penetration and reach among farmers. One of the farmers has used the government-supplied culture as mother culture and replicated the microbial consortia in 200L water with 2kg jaggery enhancement creating a large-volume base through controlled microbial multiplication rather than direct product use. The cultivated microbial formulation is sold as waste decomposer which he encourages the buyers to sub-culture and reuse as well. The preparation requires clean conditions and proper sugar nutrition to support microbial growth during the replication phase, followed by application to organic waste materials for accelerated decomposition rather than direct crop application.

### 5.2.13 Micronutrient Karaisal

Micronutrient karaisal is used only by two farmers across the sample farmers covered under the study. These micronutrient karaisals are specialized extracts targeting specific mineral deficiencies through food-based sources and metal extraction techniques. The formulations address specific micronutrient needs using indigenous knowledge of mineral-rich materials, such as erukku leaves for boron, drumstick for iron, tamarind for zinc, copper wire extraction for copper supplementation, and food mapping for comprehensive nutrition. The source materials like erukku leaves or curd and copper, or other vegetative sources are fermented for 15 days and the concentrate is applied to the field as the source of micronutrients to the soil. Table 35 gives details related to various micronutrient karaisals.

***Table 35 Ingredients and their role: Micronutrient karaisal***

| Deficiency Target | Source Material | Preparation Method | Application Rate | Specific Purpose |
|---|---|---|---|---|
| Boron Karaisal | Erukku leaves | 7 days fermentation in water | Not specified | Mitigating boron deficiency |
| Thayir Copper karaisal | Copper wire + 10L sour curd | Copper wire dipped for 15 days | 1L per 10L tank | Disease prevention treatment |
| Multiple micronutrients | drumstick (iron), tamarind (zinc), Papaya, etc, | Fermented for 7 days | Not specified | Comprehensive micronutrient supply |

*Notable observations*

- Farmers generally consider micronutrients managed through appropriate organic practices and no specific formulation is required particularly for micronutrients.

- In areas with specific micronutrient deficiencies, innovative solutions are developed to address these issues.

### 5.2.14 Humic Acid

Two famers have reported application of commercially available humic acid formulation for improved soil health. One of the farmers has used humic acid along with Jeevamirtham for its potential complimentary roles in improving the nutrient availability and soil structure. Farmer reported applying 1Kg per acre through irrigation channels. Humic acid improves the quality of soil organic matter and enhances nutrient retention and availability rather than direct nutrition source.

*Notable observations*

The practice represents the intersection of organic farming with commercial organic inputs, showing selective adoption of scientifically validated soil amendments where farmers find them compatible with organic principles.

## 5.3 Pest and disease management

In this section, we discuss the pest and disease management practices adopted by the expert and trainer farmers interviewed across 8 districts in Tamilnadu. The field documentation reveals that farmers across Tamil Nadu have developed an extensive set of pest management practices that includes 14 distinct formulations discussed in this section. These practices range from simple leaf extracts requiring minimal processing to complex fermented preparations involving multiple ingredients and extended preparation times. The adoption patterns show remarkable consistency in core practices like Poochiveratti (leaf extracts) and 3G Karaisal (garlic-ginger-green chili), while also indicating significant regional innovations and traditional knowledge.

Pest and disease management in organic farming systems operates on fundamentally different principles compared to conventional chemical agriculture. Rather than relying on single-molecule active ingredient based synthetic pesticides that target pest through acute toxicity, traditional organic formulations employ multi-compound botanical extracts that work through diverse mechanisms including antifeedant effects, growth regulation, behavioral disruption, and immune system activation in plants. This complexity creates pest management systems that are systemic in approach and simultaneously advanced in their ecological integration.

In the following section we dwell deeper into the details of each of the pest management practices reported by the farmers interviewed for the study. For each practice, three key aspects are discussed. The first aspect includes the principle and purpose of the practice, usage pattern among the farmers covered under studied, and any contextual relevance of the practice. The second aspect includes the core composition and methods of the formulation or practice along with their diversity and similarities among farmers studied. The third aspect highlights any distinct, innovative, or noteworthy observations from farmers regarding the formulation or practice.

### 5.3.1 Poochiveratti/Illai karaisal/leaf extracts

Poochiveratti, literally meaning "insect-killer" in Tamil, represents the most widely adopted botanical pest management practice across the districts studied, involving fermented extracts of multiple pesticidal plant leaves which is applied as foliar sprays for broad-spectrum pest control. With 14 farmers (30% of the sample) actively implementing the formulation, this is one of the prominent approaches adopted by organic farmers across the districts covered under the study.

While a diverse set of plants are used for the preparation of poochiveratti, analyzing the plant usage matrix reveals a distinctive pattern where four species emerge as the most frequently utilized plants across farmer formulations. It includes Yerukku (Giant Milkweed), Neem, Nochi, Alovera, and Thumbai. This pattern suggests a core set of universally recognized pesticidal plants that farmers consistently include, while individual practitioners supplement with additional species based on local availability, traditional knowledge, and specific pest challenges.

With a large range of plants used for preparation of poochivaratti, farmers employ a prudent tri-categorical plant selection system where 3-4 plants from each of the categories is used for an effective multi-modal and complementary pest control mechanisms and practical adoptability of the practice. This traditional classification represents a remarkable convergence of observations and functional biochemistry that mirrors our understanding of multi-modal pest management strategies.

The first category comprises milky or latex-producing plants including Yerukku, Alovera, Neem, and Papaya, which serve as the primary toxicity agents in the formulation. These plants provide direct toxic effects through cardiac glycosides, latex compounds, and proteolytic enzymes that operate at the cellular level. Farmers recognize these plants by their characteristic milky sap and understand intuitively that this latex contains powerful compounds capable of killing or debilitating insect pests.

The second category encompasses bitter plants such as Neem, Nochi, Thumbai, and various indigenous bitter species that create strong antifeedant effects suppressing insect feeding behavior. The purpose of including these plants extends beyond simple toxicity to modify pest behavior at the sensory level, where bitter compounds trigger feeding deterrence through insect chemoreceptors. This category demonstrates farmers' understanding that pest management requires not just killing insects but also to repel them or prevent them from feeding on crops.

The third category consists of aromatic plants including Tulasi, Curry leaf, and regional aromatic species that provide behavioral disruption through volatile compounds. These plants serve to mask host plant odors and interfere with insect navigation and host-finding behaviors. Farmers recognize that the strong fragrances of these plants create a protective aromatic shield around treated crops.

### *Core practice and diversity*

The core composition of Poochiveratti formulations demonstrates remarkable consistency in basic structural principles while accommodating significant regional variation in specific plant selection and processing methods. Table 36 below give the list of ingredients used along with their role and Table 37 below gives other application parameters like fermentation period, frequency, etc.

***Table 36 Ingredients and their role: Poochiveratti***

| Ingredient | Role / Function | Range in practice |
|---|---|---|
| Milky plant leaves | Insect deterrent compounds | 3-5 types (few bunches) |
| Bitter leaves | Pest suppression | 3-5 types (few bunches) |
| Aromatic leaves | Repellent properties | 3-5 types (few bunches) |
| Cow urine | Fermentation medium | 10–20 L |
| Water | Medium | 200 L |
| **Optional** | | |
| Oil Cake Addition | Active compounds | 0-1 kg per 200L |
| 3G karaisal (Ginger, Garlic, Green chilli) | Pest deterrent | 0-1 kg per 200L |
| Turmeric | Pest suppression | 0-0.5Kg |
| Lemon | Extraction aid | 4 pieces per batch |

***Table 37 Application and process parameters: Poochiveratti***

| Parameter | Range in practice |
|---|---|
| Batch size | 20–200 L vessels using water or gomutram |
| Fermentation duration | 7–30 days; some formulations 13 days |
| Stirring needs | Daily stirring |
| Application method | Foliar spray (filtered extract) |
| Dilution needs (if any) | 0.5–1 L per 10–16 L tank |
| Dosage / Volume per acre | ~6–10 spray tanks per acre |
| Timing / Frequency | Preventive spray; once every 15–20 days or based on pest observation |
| Shelf life | Up to ~6 months |

A typical formulation for a 10-liter batch incorporates five to ten distinct plant species with median usage of seven different plants, totalling 0.5 to 1.5 kilograms of fresh plant material where dominant species like Neem or Yerukku comprise 40 to 60 percent of the total with supporting species contributing the remaining proportion. The fermentation medium shows strong preference for cow urine, utilized by 85 percent of practitioners in volumes of 10 to 20 liters, while the remaining 15 percent employ water-based alternatives often reflecting resource constraints or specific crop sensitivity considerations. With fermentation durations ranging from 7 to 30 days, modal practice settling at 10 to 15 days represent optimal balance between compound extraction efficiency and practical time constraints, requiring daily stirring to prevent anaerobic decomposition while ensuring thorough mixing of bioactive compounds.

The standard preparation methodology followed by about 80 percent of farmers involves initial material preparation through coarse chopping or grinding of fresh plant materials, creating adequate surface area for compound extraction while maintaining cellular integrity that prevents excessive degradation. Double cloth filtration ensures removal of particulate matter that could clog spray equipment while retaining dissolved active compounds in the final preparation. Application involves tank mixing with dilution ratios varying from 1:10 to 1:100 depending on formulation concentration, pest pressure intensity, and crop sensitivity, with median dilution of 1:10 representing the most commonly adopted standard that balances efficacy with resource conservation.

*Notable observations*

- A few farmers insisted pounding the plant materials to "puttu-like consistency" before fermentation for a good extraction of active compounds.
- Farmer suggest that 10-15 days represents optimal extraction-efficiency balance and emphasized the importance of daily stirring as it is essential for aerobic conditions and compound development.
- Farmers also suggest that the material of the container for fermentation or storage should be a non-metal to prevent compound degradation.
- A few farmers add enhancers like lemon, 3G karaisal, turmeric, etc. and find it useful for an effective formulation.
- Some farmers indicated the phytotoxicity risks requiring cautious application for young saplings and sensitive crops. Appropriate dilution before application is advised to avoid any leaf burn symptoms.
- Farmers suggested alignment with weather conditions like preference for evening spraying and timing the spray with pest life cycle would effective.

Methodological diversity emerges most prominently in the sophisticated variations practiced by about 20 percent of farmers who have developed advanced processing techniques. Sequential extraction methods involve individual plant processing where each species undergoes separate fermentation before controlled mixing in specific ratios, allowing precise management of compound interactions and optimization of synergistic effects. Heat treatment alternatives employ boiling processes that enhance potency through concentrated extraction while extending shelf life from typical 15-30 days to six months, particularly valuable for farmers unable to prepare frequent fresh batches due to labor or time constraints. pH adjustment techniques incorporate ash or lime additions for optimal pH balance, recognizing that slight alkalinity enhances certain compound stability while moderate acidity favors others, demonstrating sophisticated understanding of chemical equilibria in complex botanical mixtures.

*Scientific literature*

Farmers' tri-categorical logic of milky/latex (toxicity), bitter (antifeedant), and aromatic (repellent/behavioural disruption) plants, combined with cow urine fermentation and regular low-dose spraying, is strongly supported by biochemical and field evidence on botanicals and plant-based pest management literature. Scientific work also echoes farmer cautions about phytotoxicity at higher concentrations and the need for appropriate dilutions and timing relative to crop stage and pest life cycle.

Studies in India and Abroad show that key plants used by farmers neem (Azadirachta indica), Vitex nigundo (nochi), Ocimum spp. (tulasi), citrus/lemon, garlic, chilli, Lantana, etc. contain diverse bioactive compounds (azadirachtin, nimbin, vitexin, vasicine, essential oils, sulphur compounds, capsaicin) act as toxicants, antifeedants, repellents, oviposition deterrents and growth regulators.

Though scientific literature robustly supports the building blocks and the rationale of poochiveratti (multi-plant botanicals, cow-urine ferments, behavioural and toxic modes of action), but offers only scattered, indirect evidence on formulations identical to those farmers are using. Being a widely adopted and crucial practice for pest management, it is of imminent need for an indepth research with the spectrum of this formulation to understand dose–response, toxicity, phyto-safety limits, etc., for a better adoption and application. Table 38 gives a snapshot of relevant literature and their key findings along with their references.

***Table 38 Supporting literature: Poochiveratti***

| **Farmer observation / function** | **Key finding from literature** | **References** |
|---|---|---|
| Broad-spectrum pest control with milky + bitter + aromatic plants for multi-modal control | Multi-leaf indigenous cocktails give 40–70% pest reduction in vegetables/coriander. | (Meenaa et al., 2021) |
| Bitter plants (neem, Vitex/nochi, Thumbai) as antifeedant/repellent | Neem and Vitex compounds show mortality, strong antifeedant, repellent and oviposition-deterrent activity. | (Ngegba et al., 2022; Dougoud et al., 2019) |
| Aromatic plants (tulasi, curry leaf, etc.) disrupt insect orientation | Aromatic plant extracts (e.g., Ocimum, Lantana) act as toxic and repellent botanicals. | (Meenaa et al., 2021; Ngegba et al., 2022) |
| Cow urine as fermentation medium and synergist | Cow-urine–based neem–nochi–adhatoda extract reduced rice BPH/GLH by ~67–72%. | (Ganesan et al., 2025) |
| 7–15 days fermentation with daily stirring improves efficacy | Fermented leaf–cow-urine mixtures (10–20 days) widely used; longer ferments often more effective than fresh. | (Meenaa et al., 2021; Sarma et al., 2025) |
| Foliar spray at ~1:10 dilution, repeated every 10–15 days | Documented ITK sprays use ~1:10 dilution and repeated applications for season-long control. | (Meenaa et al., 2021; Bhattarai & Bastakoti, 2023) |
| Lower harm to natural enemies than synthetics | Cow-urine–based neem–nochi–adhatoda extract had moderate, | (Ganesan et al., 2025) |

| | | |
|---|---|---|
| | lower impact on predators vs. chemicals. | |
| Phytotoxicity risk at high concentration; need dilution for young crops | Reviews stress need to optimize concentration; crude botanicals can injure crops if over-concentrated. | (Dougoud et al., 2019) |
| Enhancers like lemon, garlic–ginger–chilli, turmeric improve efficacy | Garlic–chilli and citrus extracts significantly reduce rice stem borer, leaf folder and hoppers. | (Bhattarai & Bastakoti, 2023) |
| ITK/poochiveratti as core tool in organic/low-input pest management | Indian ITK surveys show neem–cow-product–multileaf cocktails are central, effective, low-cost options. | (Meenaa et al., 2021; R et al., 2024) |

### 5.3.2 Punnaku Karaisal (Oil Cake Extract)

Punnaku Karaisal represents a nutrient-rich fermented formulation utilizing oil cakes (seed residues after oil extraction) that serves dual purposes as both a pest management agent and growth promoter in Tamil Nadu's organic farming systems. With 3 farmers (6% of the sample) actively implementing various oil cake-based formulations. This practice demonstrates sophisticated integration of agricultural by-product valorization with pest control strategies.

The fundamental principle underlying Punnaku Karaisal operates through the combination of residual bioactive compounds in oil cakes with fermentation-enhanced nutrient availability and mild pesticidal properties. Oil cakes retain significant quantities of fatty acids, proteins, and plant-specific compounds that provide both nutritional value to crops and deterrent effects against pests. The fermentation process in cow urine or water breaks down complex proteins and oils into more readily available forms while potentially creating secondary metabolites with enhanced bioactivity. This dual-action mechanism makes Punnaku Karaisal particularly valuable as it addresses both plant nutrition deficiencies and pest pressure simultaneously, representing an economically efficient use of agricultural byproducts.

The practice shows particular relevance in regions where oilseed processing is common, providing ready access to groundnut, coconut, sesame, and castor oil cakes. Farmers report using Punnaku Karaisal primarily as a growth promoter applied during critical crop development stages, with secondary benefits of pest deterrence particularly against soil-dwelling pests and nematodes.

*Core practice and diversity*

The core composition of Punnaku Karaisal formulations demonstrates significant diversity in oil cake selection and processing methods while maintaining consistent fermentation principles. The following tables summarize the ingredient quantities and process parameters documented across farmer practices. Table 39 below give the list of ingredients used along with their role and Table 40 below gives other application parameters like fermentation period, frequency, etc.

*Table 39 Ingredients and their role: Punnaku karaisal*

| Ingredient | Role / Function | Range in practice |
|---|---|---|
| Oil cakes (groundnut, sesame, neem, etc.) | Nutrient & pest deterrent | 5–20 kg (1-5 varieties) (Some avoid need cake) |
| Cow urine | Carrier base | 20L |
| Optional | | |
| Kitchen waste / fruit | Fermentation support | Equal proportion in some cases |
| Papaya extract | Sugar source | 2 L |
| Meenamilam | Microbial enrichment | 1 L |
| Amudha karaisal | Microbial dilution | 20 L |

*Table 40 Application and process parameters: Punnaku karaisal*

| Parameter | Range in practice |
|---|---|
| Batch size | 5–50 kg oil cakes (groundnut, sesame, coconut, neem etc.) in 20–200 L water |
| Fermentation duration | 2–10 days; some semi-solid pre-fermentation |
| Stirring needs | Daily stirring |
| Application method | Soil application, fertigation, occasionally foliar spray |
| Dilution needs (if any) | Often applied directly or diluted in irrigation water |
| Dosage / Volume per acre | ~40–100 kg oilcake equivalent per acre |
| Timing / Frequency | Early crop stage (30-50 days after sowing): 1-2 per crop |
| Shelf life | 7-30 days |

A typical Punnaku Karaisal formulation for a 200-liter batch incorporates 5-20 Kg of mixed oil cakes form the primary base to which country sugar or squashed fruit is added followed by addition of water or cow urine to create semi-solid to liquid consistency suitable for fertigation or soil drench applications. Fermentation periods of 7 to 10 days with daily stirring ensure proper breakdown of oil cake components while preventing anaerobic putrefaction. A few farmers enhance the formulation with other organic inputs like meenamilam or amirthakaraisal, creating an enriched formulation that provide broader nutritional profiles and potentially synergistic pest control effects.

### *Notable Observations*

- Farmer Muniyan's approach of multi-source oil cake and particularly avoiding neem cake illustrate the focus on growth promotion role than the pest management needs.
- Farmer Vijay's integration with meenamilam and amirthakaraisal indicates the experimental approach for a comprehensive soil enrichment practice.
- Farmers indicate that with the shift away from traditional cold-pressed oil extraction had reduced the availability of good quality oil cakes in the market. Often the presence of local processing units becomes an important factor for the availability of cost effective and good quality oil cakes.

### *Scientific literature*

Use of punnaku karaisal reflects two strongly supported scientific roles of oil cakes which includes nutrient-rich organic amendments and sources of bioactive pest-suppressive compounds. Oil cakes are widely recognised as nutrient-dense by-products suitable for fertilizers, soil amendments, enzyme/bioproduct production and phytonematode management. In Indian organic farming, oil cakes (especially neem, pungam, mahua, groundnut, etc.) are routinely combined with other organic inputs to enhance soil fertility, microbial activity and crop yield.

There is a strong, but indirect, scientific evidence for the core concepts underpinning Punnaku Karaisal. Fermentative processing of oil cakes has been shown to enhance recovery and activity of bioactive compounds with antimicrobial and phytopathogen-inhibiting properties. However, field-level performance and mechanism of phytonematode control and antifungal activity are incompletely understood, and more work is needed to characterise modes of action, optimal doses, etc. Table 41 gives the list of relevant literature along with their key findings and references.

***Table 41 Supporting literature: Punnaku karaisal***

| Farmer observation / function | Key relevant findings from literature | References |
|---|---|---|
| Enhances soil fertility and nutrient availability | Oilseed cakes are rich in protein, nitrogen and minerals and are widely used as plant conditioners and compost amendments, improving soil nutrient status. | (Singh et al., 2022) |
| Acts as plant nutrient enhancer / growth promoter and better yield | Oil cake extracts used as seed priming (“orgo-nutri priming”) in groundnut increased germination, root and shoot length, dry matter and vigour index, showing clear growth-promoting effects. | (Manonmani et al., 2023) |
| Suppresses soil-borne diseases (fungi, some bacteria) | Ethanolic extracts of several oilseed cakes significantly inhibited soil-borne fungal pathogens Fusarium oxysporum and Rhizoctonia solani and pathogenic bacteria in vitro, indicating strong antimicrobial potential for disease management. | (Mehak, 2023) |
| Manages plant-parasitic nematodes in soil | Review of oil-cake amendments (neem, mustard, castor, groundnut, sesame, etc.) shows consistent suppression of phytonematodes (e.g. Meloidogyne spp.) in glasshouse and field. | (Sumbul et al., 2015) |
| Promotes beneficial microbes / biological activity | Oil cakes are highlighted as rich substrates for fermentative production of enzymes, antibiotics and other bioproducts, reflecting their capacity to support diverse beneficial microorganisms during bioprocessing and in agricultural applications. | (Dhandapani & Sambasivam, 2025) |
| Provides bioactive compounds with pesticidal potential | Chemical profiling of seed cakes shows substantial phenolics and antioxidant activity retained after oil extraction, supporting their potential as raw materials for natural biopesticides and biofertilizers in circular farming systems. | (Šarac et al., 2025) |

### 5.3.3 Moor Karaisal/Theimoor Karaisal (Buttermilk-Based Formulation)

Moor Karaisal, also known as Theimoor Karaisal (literally "sour buttermilk extract"), represents a distinctive fermented formulation utilizing buttermilk as the primary active ingredient, often enhanced with coconut milk or other complementary materials. Nine farmers (17% of the sample) implementing this practice across five districts (Cuddalore, Chengalpattu, Salem, Pudukottai, and Dindigul). This formulation occupies a special position with the ease of availability and preparation process for organic farming pest and disease management systems, particularly valued for its application during flowering stages and for managing viral diseases.

The fundamental principle underlying Moor Karaisal operates through multiple complementary mechanisms that distinguish it from purely botanical pest control formulations. The lactic acid bacteria present in fermented buttermilk create an acidic environment on leaf surfaces that inhibits fungal spore germination and bacterial pathogen proliferation, while the protein content in buttermilk provides nutrient supplementation during critical reproductive phases. The fat globules in buttermilk and coconut milk create a thin coating on plant surfaces that serves dual functions: acting as an adhesive carrier for other compounds while simultaneously creating a physical barrier that reduces pathogen penetration and minor pest feeding. The fermentation process enhances these properties by generating organic acids and bioactive metabolites that provide additional antimicrobial effects.

Farmers specifically emphasize moor karaisal's role as a flowering promoter and flower retention agent, typically applying the formulation during the flowering stage. The acidic nature of the formulation is believed to help flowers adhere more firmly to plants, preventing premature dropping that commonly occurs during pest attack, environmental stress, or nutrient deficiency. Additionally, farmers report effectiveness against viral diseases, suggesting that the formulation may interfere with viral transmission by insect vectors or enhance plant systemic resistance through nutritional and microbial support.

*Core practice and diversity*

The core composition of Moor Karaisal formulations shows moderate variation in ingredient selection while maintaining consistent fermentation and application principles. The practice centers on sour buttermilk as the primary functional ingredient, with optional enhancements including coconut milk, fruit extracts, and occasionally other organic materials. Table 42 below give the list of ingredients used along with their role and Table 43 gives other application parameters.

***Table 42 Ingredients and their role: Moor karaisal***

| Ingredient | Role / Function | Quantity – Range in practice |
|---|---|---|
| Sour curd / buttermilk | Lactobacillus source | 6–10 L per acre |
| Coconut (grated/milk) | Enhances microbial activity | ~10 coconuts (1:1 coconut milk) |
| Water | Dilution | 3:4 to 1:32 (Quality of buttermilk) |

*Table 43 Application and process parameters: Moorkaraisal*

| **Parameter** | **Range in practice** |
|---|---|
| Batch size | 5–10 L |
| Fermentation duration | 3–10 days (anaerobic in some cases) |
| Stirring needs | Minimal; usually closed fermentation |
| Application method | Foliar spray |
| Dilution needs (if any) | ~0.5–2 L per 10–16 L spray tank |
| Dosage / Volume per acre | ~8–10 spray tanks per acre |
| Timing / Frequency | Flowering or fruiting stage; 1–2 rounds per crop |
| Shelf life | Short; used soon after preparation |

The standard preparation methodology involves preparation of buttermilk from 3-5 days old curd and fermented for 7 to 10 days with optional addition of coconut milk for nutrient supplement at a varying level. The coconut component is typically added at 1:1 ratio with buttermilk, creating a rich, emulsified formulation that resists rain washoff better than water-based preparations.

### *Distinctive Innovations and Notable Observations*

- A few farmers have enhanced the formulation with addition of arrappu (oil cake tree leaves) in the moor karaisal as a replacement to coconut milk emulsification.
- Farmer Aravazhi suggests that theimoorkaraisal is applied twice with 15 days apart, covering the flower initiation period through early fruit set. This dual application ensures continuous protective and nutritional support during the extended flowering period common in many vegetable and fruit crops.
- The dilution ratios vary from relatively concentrated applications to more dilute sprays, reflecting differences in crop sensitivity, environmental conditions, and farmer experience with optimal concentrations for specific crops.
- Theimoor karaisal is often cited as very effective control agent of viral diseases in crop production.
- Farmer Kumar has substituted coconut milk with grated coconut (1 coconut per litre of buttermilk) and found it as effective as the one with coconut milk.
- Key quality parameters would include the pleasant sour smell indicating proper fermentation and clear formulation withour mold formations.

### *Scientific literature*

Scientific work from India and elsewhere increasingly shows that fermented dairy liquids such as buttermilk are rich in lactic acid bacteria and organic acids, which can acidify substrates, confer antimicrobial effects, and act as carriers of beneficial microbes and bioactive compounds.

Buttermilk-based and dairy ferments are scientifically recognized as highly active lactic acid systems with organic acids, antioxidants, flavonoids and diverse LAB that can generate antimicrobial and functional metabolites. However, direct, named studies on Moor Karaisal/Theimoor Karaisal itself are not yet available in the indexed literature. Table 44 gives list of supporting literature along with their key findings and references.

*Table 44 Supporting literature: Moore karaisal*

| Farmer observation / function | Key relevant findings from literature | References |
|---|---|---|
| Foliar spray of liquid buttermilk to reduce viral disease | 20% buttermilk spray gave lowest virus incidence (50.8%) and severity (21.3%) versus other biostimulants and control, across two years. | (Dhkal et al., 2022) |
| Foliar spray of liquid buttermilk increases yield and fruit traits | 20% buttermilk increased fruits/plant, marketable fruits, and fruit weight (≈983 g) and improved chlorophyll and photosynthesis compared with control. | (Dhkal et al., 2022) |
| Buttermilk as acidulant in rock-phosphate compost and improves P availability | Buttermilk-acidulated RP compost raised cotton yields in all 61 trials; soybean and most wheat trials also improved. Farmers identified buttermilk as the most available, affordable acidifying agent. | (Cicek et al., 2020) |
| LAB-rich, sour buttermilk as base medium | Buttermilk and cultured buttermilk are naturally rich in LAB such as Lactococcus lactis and Lactiplantibacillus plantarum, plus proteins, fat-globule membrane phospholipids and minerals. | (Karssa et al., 2024; Kondrotiene et al., 2023) |

### 5.3.4 Agnihastram (Herbal Repellent)

Agnihastra, literally meaning "fire weapon" in Sanskrit, represents an intensive herbal pest repellent formulation that combines strong pesticidal plants through a heat-extraction process. With 4 farmers (9% of the sample) implementing this practice across three districts (Cuddalore, Salem, and Dindigul), this formulation is often considered as an emergency pest control practice as it is adopted in two scenarios. One, when the fermentation based poochiveratti fails to control the pest and the second is when the farmer have very limited time to prepare the pest formulation.

This pest control practice occupies a specialized position as a high-potency intervention reserved for severe pest infestations or pest-prone crops where standard botanical extracts prove insufficient. The preparation distinguishes itself from fermented leaf extracts through its heat-based extraction methodology involving multiple boiling cycles that concentrate bioactive compounds while extending shelf life significantly. Farmers report that this formulation functions as a powerful broad-spectrum repellent and contact insecticide, with the name "Agnihastra" reflecting both its intensive preparation through fire and its aggressive pest control action. The practice demonstrates farmer understanding that certain pest situations require more concentrated interventions than standard fermented preparations can provide.

The reported mechanisms through which Agnihastra operates include strong repellent effects from concentrated volatile compounds, contact toxicity from high concentrations of botanical alkaloids and phenolic compounds, antifeedant properties that prevent pest feeding even when insects are present on crops, and potential systemic effects when absorbed through leaf tissues. The heat extraction process is believed by practitioners to enhance compound concentration while reducing the water content that could decrease microbial activity and results in stable preparations with extended usability. The combination of tobacco (containing nicotine alkaloids), neem (azadirachtin and related compounds), and pungent spices (capsaicin from chili, allicin from garlic) creates what farmers describe as an overwhelmingly hostile environment for pests.

The contextual relevance of Agnihastra extends beyond routine pest management to represent a strategic tool for crisis intervention during pest outbreaks. The relatively low adoption rate reflects both the labor-intensive preparation requirements and the recognition that such intensive formulations should be reserved for situations where gentler approaches prove inadequate.

### *Core practice and diversity*

The core composition of Agnihastra formulations shows moderate consistency in basic ingredients while demonstrating variation in proportions and processing intensity. All documented formulations include neem as the botanical base, tobacco for alkaloid potency, and garlic-chili complex for pungent repellent effects, creating a multi-compound mixture with complementary pest control mechanisms. Table 45 below give the list of ingredients used along with their role and Table 46 gives other application parameters like fermentation period, frequency, etc.

***Table 45 Ingredients and their role: Agnihastram***

| Ingredient | Role / Function | Range in practice |
|---|---|---|
| Neem leaves | Pest suppression | 1-5 kg |
| Garlic, ginger, chilli | Repellent mix | 0.25-0.5 kg each |
| Tobacco | Strong insecticidal property | 0.25-0.5 kg |
| Cow urine / water | Extraction medium | 10 L |
| Concentrated yield | After heating | 6-7L per 10L batch |

***Table 46 Application and process parameters: Agnihastram***

| Parameter | Range in practice |
|---|---|
| Batch size | Neem leaves (1–5 kg), garlic, chilli, tobacco, gomutram; boiled mixture yielding ~3–10 L concentrate |
| Fermentation duration | Boiled; 24 hrs cooling/settling |
| Stirring needs | Mixing during boiling |
| Application method | Foliar spray |
| Dilution needs (if any) | 40–100 ml per 10–16 L spray tank |
| Dosage / Volume per acre | 0.4-2 L per acre |
| Timing / Frequency | Pest incidence or preventive use |
| Shelf life | 6 months - 2 years |

The standard preparation methodology involves an intensive multi-stage heat extraction process that distinguishes Agnihastra from cold-fermented formulations. The process begins with grinding or chopping all plant materials and spices to maximize surface area, followed by combining with cow urine or water in large vessels suitable for sustained boiling. The mixture undergoes three successive boiling cycles where it is brought to boil, simmered for extended periods, and allowed to cool between cycles. This repeated heat application serves multiple purposes that includes extracting heat-stable alkaloids and phenolic compounds from plant tissues, concentrating the solution through water evaporation, sterilizing the preparation to prevent microbial degradation, and creating a shelf-stable product requiring no refrigeration.

The boiling process typically reduces the initial volume by approximately to 60-70 percent, transforming a 10-liter initial mixture into 6-7 liters of concentrated extract. After the final boiling cycle, the mixture cools for atleast 24 hours. The cooled preparation is then filtered through cloth to remove solid residues, yielding a dark, aromatic liquid with strong pungent odor. The resulting concentrate requires significant dilution before field application, with typical ratios of 4-30ml per litre and about 8-10 tanks (10L) of spray per acre resulting in 400ml-3L per acre.

### *Distinctive Innovations and Notable Observations*

- Farmers monitor the boiling carefully to prevent overheating and stop the heating as soon as the formulation is close to boiling point. While achieving sufficient concentration is the focus, farmers recognize that over-boiling can degrade certain compounds and under-boiling leaves the preparation ineffective.
- With inputs like garlic, chilli, and tobacco, the cost of preparation of the formulation often goes upto Rs.300 per litre.
- Preparation requires 6-8 hours of active attention during boiling and are often prepared during off-season when labor availability is not a problem.
- Since the resulting formulation is a concentrate of a range of phytochemicals, farmers suggest a cautious selection of dosage especially for young crops and sensitive crops to avoid burning of leaves or any other adverse impact on crops. Some farmers suggest one day observation in pilot plot before applying to the entire farm.

### *Scientific literature*

The key plants in Agnihastra all contain well-documented bioactive compounds: azadirachtin and related limonoids in neem; nicotine alkaloids in tobacco; organosulfur compounds in garlic; and capsaicinoids in chili, collectively provide repellent, contact toxicity and antifeedant effects. Farmer emphasis on process intensity, pulverizing ingredients, using cow urine or water, and repeated boiling to concentrate and stabilize the extract has clear parallels in the literature. Extraction time, processing and formulation markedly affect active ingredient concentration and performance in neem-based homemade extracts. Both heating and steeping increase release of bioactive compounds from garlic–chili mixtures used as botanical insecticides.

A substantial body of work on homemade botanical insecticides prepared from neem, garlic, chili and tobacco, including water- and urine-based extracts are available. However, most of the studies use cold macerations filtered and used directly and systematic work on long-term health, environmental safety, and exact shelf-life behaviour of such concentrates is still limited. Table 47 gives the supporting literature along with the key findings and references.

***Table 47 Supporting literature: Agnihastram***

| Farmer observation / function | Key relevant findings from literature | References |
|---|---|---|
| "Crisis tool": stronger mix when milder sprays fail | Higher loading or optimized extraction improves control in high pressure. | (Dougoud et al., 2019; Isman, 2005) |
| Strong antifeedant: pests present but feed less | Neem (azadirachtin) is a potent antifeedant; homemade neem sprays reduce feeding damage in field crops. | (Dougoud et al., 2019; Kaur et al., 2023) |
| Mainly repellence/ avoidance of treated foliage | Botanical repellents act via olfaction and gustation; neem- and spice-based sprays show strong repellency. | (Ngegba et al., 2022; Mohamedfarook et al., 2024) |
| Risk of phytotoxicity at high concentration; need test plot | Reviews stress dose optimisation; concentrated homemade botanicals can cause phytotoxicity if overdosed. | (Dougoud et al., 2019; Tavares et al., 2021) |
| Heat extraction, multi-boiling improves concentration and shelf life | Efficacy and stability of botanicals depend strongly on extraction method, solvent and process standardisation. | (Dougoud et al., 2019; Tavares et al., 2021) |
| Tobacco adds rapid "fire" contact toxicity | Nicotine from tobacco is a fast-acting botanical insecticide with strong contact toxicity. | (Hikal et al., 2017; Pais-Chanfrau et al., 2025) |
| Cow urine as carrier/adjuvant | Neem–cow urine and other cow-urine–botanical mixes significantly suppress sucking pests in Indian field trials. | (Ganesan et al., 2025; Dinkar et al., 2024) |
| Long shelf life of concentrated stock | Stability of plant insecticides improves with controlled extraction/formulation; water content and microbes are key. | (Dougoud et al., 2019; Tavares et al., 2021) |

## 5.3.5 Karpura Karaisal (Camphor-Based Formulation)

Karpura Karaisal represents a volatile aromatic formulation centered on camphor as the primary active ingredient, combined with neem oil, botanical additives, and emulsifiers to create a potent pest repellent and potential disease management spray. With 3 farmers (7% of the sample) implementing this practice across two districts (Salem and Dindigul), this formulation focusses on addressing pests sensitive to volatile aromatic compounds and situations requiring strong repellent action combined with contact toxicity.

Farmers report its effectiveness during flowering stages for pest control and flower/fruit retention. The formulation is often used when conventional water-based sprays may prove insufficient and control volatile-sensitive pests like thrips. The reported mechanisms through which Karpura Karaisal operates include strong volatile repellent effects where camphor's penetrating aroma creates a protective aromatic barrier that insects actively avoid, contact toxicity from the combination of camphor, neem oil, and botanical compounds affecting insect nervous systems and cuticle integrity, behavioral disruption preventing pest feeding, mating, and oviposition in treated areas, and potential antimicrobial effects against fungal and bacterial pathogens. The formulation's complexity involving dissolution of camphor in alcohol or oil, emulsification for water compatibility, and integration with complementary pest control compounds demonstrates sophisticated understanding of chemical compatibility and formulation stability requirements.

### *Core practice and diversity*

The core composition of Karpura Karaisal formulations demonstrates moderate consistency in basic structure while showing significant variation in quantities and preparation methods reflecting different farmer innovations and resource availability. Table 48 below give the list of ingredients used along with their role and Table 49 gives other application parameters like fermentation period, frequency, etc.

***Table 48 Ingredients and their role: Karpura karaisal***

| Ingredient | Role / Function | Quantity – Range in practice |
|---|---|---|
| Camphor | Repellent | 5–10 gm |
| Eukalyptus oil | Solvent | A few drops |
| Neem oil | Pest deterrent | 75-300ml |
| Soap nut, turmeric and lime | Emulsifier | 10-50 gm |
| Water | Dilution medium | ~10 L |
| Cow urine | Pest suppressor | 0-1 L |

***Table 49 Application and process parameters: Karpura karaisal***

| Parameter | Range in practice |
|---|---|
| Batch size | 5–8 g camphor in ~10 L water; sometimes neem oil, turmeric, sunnambu added |
| Preparation Method | Sequential mixing, Camphor dissolved first followed by sequential mixing |
| Fermentation duration | Usually immediate use; some short resting |
| Stirring needs | Mixing only |
| Application method | Foliar spray |
| Dilution needs (if any) | 50–150 ml per 10 L tank |
| Dosage / Volume per acre | ~10 tanks per acre |
| Timing / Frequency | Flowering and pest management stage |
| Shelf life | Immediate use preferred |

The process begins with dissolving camphor crystals or pieces in a small volume of ethanol or eucalyptus oil, creating a concentrated camphor solution. This step proves critical as camphor does not dissolve readily in water alone, and attempting to add solid camphor directly to aqueous mixtures results in uneven distribution and poor efficacy. Once camphor is dissolved, farmers separately prepare other components like neem oil component with emulsifiers (soap or sunnambu/slaked lime) to create a stable emulsion that will not separate when combined with water. Turmeric powder is typically mixed into a paste with small amounts of water to ensure even distribution. Each component is prepared individually to ensure proper solubility and stability before final combination.

The final formulation assembly involves adding all prepared components to the bulk water volume in spray tanks, stirring thoroughly to create a homogeneous mixture. Farmers emphasize that the formulation must be prepared right before the application, to ensure the effectiveness of the application as the volatile nature of camphor is likely to reduce over time.

### *Distinctive Innovations and Notable Observations*

- Though both natural and synthetic forms of camphor share similar pesticidal functions, natural camphor is preferred under organic farming practice. However, market availability heavily favors synthetic camphor due to its lower cost and consistent supply, making it the sole choice for most farmers despite organic farming principles preferring natural sources. The practical reality is that farmers rarely have access to verified natural camphor, creating ambiguity in practice.
- Farmers warned of the possible leaf burn due to excessive use of camphor and hence suggested a judicious approach during preparation.

### *Scientific literature*

Essential oil components such as camphor, eucalyptol and linalool are well documented as having fumigant, contact, repellent and feeding-deterrent activity, and can disrupt development and reproduction of insects. Neem oil and other neem products provide complementary insecticidal and antifeedant effects, acting as ovicides, larvicides, oviposition deterrents and growth regulators via azadirachtin and related limonoids. Reports of flower/fruit retention under use of Karpura Karaisal is likely to be an indirect outcome of reduced pest feeding and oviposition.

There is substantial scientific evidence on the building blocks of Karpura Karaisal including neem oil, essential oils rich in monoterpenes like camphor, and multi-botanical mixtures. However, almost no work that tests a formulation in combination of camphor–neem–turmeric–cow urine in Indian field conditions. Table 50 gives a list of supporting literature along with the key findings and references.

***Table 50 Supporting literature: Karpura karaisal***

| Farmer observation / function | Key relevant findings from literature | References |
|---|---|---|
| Strong volatile repellent "aromatic barrier" from camphor | Essential-oil based insecticides (rich in monoterpenes) act mainly via repellency and neurotoxicity. | (Isman et al., 2011; Isman, 2020) |

| | | |
|---|---|---|
| Contact toxicity from camphor + neem oil + botanicals | Neem- and essential-oil based botanicals provide contact toxicity, antifeedant and neurotoxic effects on many insect pests. | (Adusei & Azupio, 2022; Lengai et al., 2020) |
| Particular usefulness against volatile sensitive, small pests (e.g. thrips) | Essential oil based products are most effective where short-lived but strong volatile action against soft-bodied pests is needed. | (Isman et al., 2011; Isman, 2020) |
| Need for fresh preparation; loss of effect on storage | Poor solubility, volatility, photodegradation and short shelf life are major constraints of neem and essential-oil biopesticides; advanced formulations aim to overcome this. | (Chopra et al., 2025; Campos et al., 2016) |
| Using multiple botanicals (camphor, neem, turmeric, cow urine) for broad control | Botanical pesticide combinations and neem-based mixtures are promoted in organic farming to broaden modes of action and exploit synergism. | (Reddy & Chowdary, 2021; Divekar, 2023) |
| Risk of leaf burn / phytotoxicity at high camphor doses | Possible phytotoxicity and non-target effects of concentrated botanical and essential-oil formulations. | (Sarmah et al., 2024; Chopra et al., 2025) |

### 5.3.6 3G Karaisal (Garlic-Ginger-Green Chilli)

3G Karaisal, named for its three primary ingredients namely Garlic, Ginger, and Green Chilli represents one of the widely adopted pest repellent formulations due to the usage of commonly available ingredients. 5 farmers (11% of the sample) implemented this practice across four districts (Cuddalore, Salem, Dindigul, and Pudukottai).

The reported mechanisms through which 3G Karaisal operates include strong repellent effects from pungent volatile compounds (allicin from garlic, gingerol from ginger, capsaicin from chilli) that overwhelm insect chemosensory systems, contact irritation causing immediate pest avoidance behaviors and deterring feeding and oviposition, antifeedant properties where residual compounds on leaf surfaces trigger taste receptor responses preventing pest consumption of treated plants, and potential antimicrobial effects against bacterial and fungal pathogens. The fermentation process in cow urine is believed to enhance extraction of bioactive compounds while potentially creating additional metabolites with pest control properties.

*Core practice and diversity*

The core composition of 3G Karaisal formulations shows remarkable consistency in the basic three-ingredient structure while demonstrating variation in proportions, fermentation methods, and application concentrations across different farmer practices. Table 51 below give the list of ingredients used along with their role and Table 52 gives other application parameters like fermentation period, frequency, etc.

*Table 51 Ingredients and their role: 3G karaisal*

| Ingredient | Role / Function | Range in practice |
|---|---|---|
| Garlic | Pest repellent | Equal ratio (0.5-1kg) |
| Ginger | Repellent / antimicrobial | Equal ratio (0.5-1kg) |
| Green chilli | Repellent / irritant | Equal ratio (0.5-1kg) |
| Cow urine | Fermentation medium | ~20 L |

*Table 52 Application and process parameters: 3G karaisal*

| Parameter | Range in practice |
|---|---|
| Batch size | 1:1:1 ratio ingredients; quantities range from 250 g to 1 kg each |
| Fermentation duration | 2–3 days common |
| Stirring needs | Daily stirring |
| Application method | Double cloth filtration followed by foliar spray |
| Dilution needs (if any) | 100–500 ml per spray tank (10L) |
| Dosage / Volume per acre | ~8–10 tanks per acre |
| Timing / Frequency | Pest prevention and control |
| Shelf life | 1 week |

The preparation methodology involves grinding or crushing the three spice components into a paste, fermenting the mixture in cow urine or water for 2-7 days, and applying the strained liquid as a foliar spray at significant dilutions.

The standard preparation methodology begins with sourcing garlic, ginger, and green chillies in equal proportions by weight (1:1:1), ranging from 0.5 to 1 kilogram of each component for a standard batch of 20L. All three components are ground into a coarse paste creating a pungent mixture that releases strong aromatic compounds during processing. The ground paste is transferred to fermentation containers (typically 20-liter plastic or earthen vessels) and mixed with cow urine of about 20 liters and allowed to ferment for 2-3 days. After fermentation, the mixture is strained thoroughly through double cloth filtration to remove solid particles that could clog spray equipment. The resulting liquid has an intense pungent odor characteristic of the three spices. This concentrate is then diluted for field application, typically at 1-5% depending upon pest pressure, crop sensitivity, and farmer experience.

*Notable Observations*

- 3G karaisal is considered as a middle ground between simple moor karaisal and intensive preparations like Agnihastra, offering strong pest control efficacy with moderate preparation requirements and readily available ingredients.
- Farmers flagged the need for selecting chillies with strong pungency for an effective pest control while also warning the risk of leaf burn among sensitive crops with excessive concentration of the formulation.
- Scientific studies show that garlic, ginger and chilli contain potent bioactive compounds (allicin, gingerols/shogaols, capsaicinoids) with repellent, antifeedant, ovicidal, insecticidal and antimicrobial activities. Farmer practice of

3G Karaisal is strongly consistent with scientific evidence on spice-based botanicals and cow-urine ferments as multi-mechanism, broad-spectrum, relatively safe pest management tools.

- Mechanisms and components are well documented, and closely related mixtures have field evidence. Though studies show garlic, chilli and ginger as promising biopesticide plants with repellent, antifeedant and multi-target toxic effects, there is a need for rigorous field trials under farmer conditions, standardisation of preparation and dose, and safety/side-effect assessment.

*Scientific literature*

Scientific studies show that garlic, ginger and chilli contain potent bioactive compounds (allicin, gingerols/shogaols, capsaicinoids) with repellent, antifeedant, ovicidal, insecticidal and antimicrobial activities. Farmer practice of 3G Karaisal is strongly consistent with scientific evidence on spice-based botanicals and cow-urine ferments as multi-mechanism, broad-spectrum, relatively safe pest management tools.

Mechanisms and components are well documented, and closely related mixtures have field evidence. Though studies show garlic, chilli and ginger as promising biopesticide plants with repellent, antifeedant and multi-target toxic effects, there is a need for rigorous field trials under farmer conditions, standardisation of preparation and dose, and safety/side-effect assessment. Table 53 gives the supporting literature with key findings and references.

***Table 53 Supporting literature: 3G karaisal***

| Farmer-observed function | Evidence from literature | References |
|---|---|---|
| Repels and deters feeding by pests | Garlic, chilli and ginger contain bioactive compounds with repellent and antifeedant effects in many crops. | (Dougoud et al., 2019; Hikal et al., 2017; Sinha & Ray, 2024) |
| Controls multiple rice and vegetable pests | Garlic–chilli spray in rice significantly reduced gall midge, caseworm, GLH and BPH; garlic–onion–chilli spray in cabbage cut aphids and diamondback moth larvae by ~60–70%. | (K & M, 2025; Argessa et al., 2025) |
| Cow-urine fermentation boosts efficacy and is pesticidal itself | Fermented cow urine and cow-urine–botanical mixes cause high larval mortality in Chilo partellus and other pests, and are proposed as eco-friendly alternatives. | (Nega & Getu, 2020; Ganesan et al., 2025; Kabir et al., 2022) |
| Needs standardisation of recipe and dose | Reviews of homemade and botanical insecticides emphasise variable efficacy and call for better formulation, stability and dose optimisation. | (Dougoud et al., 2019; Campos et al., 2019; Ngegba et al., 2022) |

### 5.3.7 Ennai Karaisal (Oil Mix)

Ennai Karaisal represents an oil-based pest management formulation that utilizes the pesticidal properties of various plant-derived oils, either individually or in combination, to control insect pests through both chemical toxicity and physical smothering mechanisms. With 4 farmers (9% of the sample) implementing this practice across three districts (Chengalpattu, Pudukottai and Tiruppur), this formulation is often considered as an effective alternate to water-based botanical extracts. Though farmers consider this formulation to have higher potency, use of oil makes it an expensive method to be considered pest management.

The preparation methodology involves creation of oil emulsions that can be diluted and sprayed onto crops. Unlike fermented botanical extracts that rely primarily on plant alkaloids and phenolic compounds, oil-based formulations work through multiple physical and chemical pathways. Some farmers recognize that oil applications create fundamentally different pest control dynamics compared to water-based sprays, with particular effectiveness against pests that conventional botanical extracts struggle to control.

*Core practice and diversity*

The core composition of Ennai Karaisal formulations demonstrates significant diversity in oil selection and combination strategies, reflecting both regional availability of oil sources and farmer experimentation with different oil properties for specific pest challenges. Table 54 below give the list of ingredients used along with their role and Table 55 gives other application parameters like fermentation period, frequency, etc.

***Table 54 Ingredients and their role: Ennai karaisal***

| Ingredient | Role / Function | Range in practice |
|---|---|---|
| Neem oil | Repellent | 1 L |
| Pungam oil | Repellent | 1 L |
| Illupai oil | Repellent | 1 L |
| Soapnut | Emulsifier | 100-200gm |

***Table 55 Application and process parameters: Ennai karaisal***

| Parameter | Range in practice |
|---|---|
| Batch size | 3 L |
| Fermentation duration | Usually immediate mixing (no fermentation) |
| Stirring needs | Thorough mixing before use |
| Application method | Foliar spray |
| Dilution needs (if any) | 50-100 ml per spray tank (10–16 L) |
| Dosage / Volume per acre | ~8–10 spray tanks per acre |
| Timing / Frequency | When water-based formulations could not mitigate |
| Shelf life | Short; prepared for immediate use |

The standard preparation methodology for multi-oil formulations involves combining equal parts of three primary oils: neem oil (valued for its azadirachtin content and broad-spectrum activity), pongamia oil (containing karanjin with strong insecticidal properties), and mahua/illupai oil (providing additional fatty acid profiles and pest control compounds). When boondhi kottai (soapnut) is included, it help in emulsification of oil.

At times farmers achieve emulsification by adding soap (typically ½ bar grated or dissolved) and vigorously stirring or shaking until the mixture becomes homogeneous. When properly emulsified, the oil mixture takes on a milky white appearance, indicating that oil droplets have been suspended in a stable colloidal system that will remain mixed when diluted with water. This emulsified concentrate can then be diluted at required concentration and spayed using the sprayer. Concentrate of 50-100 ml per 10-liter spray tank is usually adopted for application.

*Distinctive Innovations and Notable Observations*

- The relatively low adoption rate reflects both higher input costs compared to freely available plant materials and technical challenges in creating stable oil emulsions and preventing phytotoxicity from excessive oil application.
- Farmer John indicates that he applies Pseudomonas followed ennai karaisal for an effective control of sitting pests.

*Scientific literature*

Several studies indicate botanical oils and their micro/microemulsion formulations are promising tools for sustainable pest management and are being developed as alternatives to synthetic pesticides in IPM and agroecological crop protection. Essential and botanical oils provide contact toxicity, fumigant, repellent, antifeedant, and oviposition-deterrent effects against a wide range of crop pests and are now a central focus of “green pesticide”/biopesticide research.

There is a large and fast-growing body of research on plant-based biopesticides, especially essential and botanical oils, which directly underpins the mechanisms of Ennai Karaisal. Bibliometric analysis indicates that about 75% of publications on essential oils as biopesticides appeared in the last 5 years, with strong contributions from India among leading countries. Table 56 gives the supporting literature along with their key findings and references.

***Table 56 Supporting literature: Ennai karaisal***

| Farmer observation / function | Key relevant findings from literature | References |
|---|---|---|
| Controls broad range of sucking and chewing pests | Essential oils show contact, fumigant, repellent and antifeedant activity against many insect pests and are proposed as green bioinsecticides. | (Ngegba et al., 2022; Dougoud et al., 2019) |
| Kills insects by “suffocating” / coating with oil | Botanical oils act via physical coating plus neurotoxic/physiological disruption; fine oil droplets increase coverage of target pests. | (Mossa, 2016; Sharma et al., 2020) |

| | | |
|---|---|---|
| Mixed oils work better than single oils | Essential oils are complex mixtures; synergistic interactions among multiple constituents and blended oils can enhance bioinsecticidal efficacy. | (Mossa, 2016; Gupta et al., 2023) |
| Perceived as environmentally benign and quickly degradable | Essential-oil biopesticides are biodegradable, less persistent and have lower residue risks than conventional pesticides. | (Mossa, 2016; Ngegba et al., 2022) |
| Considered safer for users and non-targets when used properly | Reviews emphasise lower mammalian toxicity and reduced non-target impacts of many EO biopesticides compared with synthetic insecticides. | (Mossa, 2016; Devrnja et al., 2022) |
| Needs frequent reapplication; short residual effect | High volatility and instability of essential oils cause rapid degradation and short field persistence, requiring repeated applications. | (Mossa, 2016; Ibrahim, 2019) |
| Effectiveness depends on good emulsification and mixing | Micro/nanoemulsions of botanical oils greatly improve dispersion, stability and bioefficacy over crude oils. | (Gupta et al., 2023; Sharma et al., 2020) |

### 5.3.8 Kadal Paasi Thiravam (Seaweed Extract)

Kadal Paasi Thiravam (Seaweed extract) is a marine-derived bio-stimulant and bio-pesticide used in organic farming system. While commonly recognized for its growth-promoting and micronutrient properties, seaweed extracts also possess significant pest and disease management capabilities through multiple mechanisms including induced systemic resistance, antifeedant properties, and direct antimicrobial effects. With 3 farmers (7% of the sample) implementing this practice, this formulation is popular among farmers interviewed in Dindigul.

Scientific studies confirm their effectiveness in reducing a range of plant diseases and pests, with the benefits amplified by improved plant vigour. Seaweed extracts play a multi-functional role in organic pest management by inducing plant defence mechanisms, exhibiting direct antimicrobial and antifeedant effects, and promoting overall plant health. Their bioactive compounds trigger systemic resistance, suppress fungal and bacterial diseases, and deter insect pests without harming beneficial insects. Additionally, seaweed formulations enhance plant nutrient uptake and support beneficial soil microorganisms, boosting resilience against pest and disease pressure.

*Core practice and diversity*

The core composition of Kadal Paasi Thiravam formulation include one or two types of seaweed namely Kappaphycus and Sargassum sp. Farmers purchase the raw materials for the formulation from a start-up based out of Gandhigram Rural Institute in Dindigul. The preparation methodology of the formulation starts with washing of the seaweeds in fresh water to remove salt. About 1kg of seaweeds is heated to pre-boiling state in 50L of water to extract soluble compounds. This creates the concentrate which is filtered and then diluted for field application at approximately 100-200ml per 10-liter spray tank.

Table 57 below give the list of ingredients used along with their role and Table 58 gives other application parameters like fermentation period, frequency, etc.

***Table 57 Ingredients and their role: Kadal paasi thiravam***

| Ingredient | Role / Function | Range in practice |
|---|---|---|
| Pepsi Paasi (Kappaphycus) | Growth stimulant, micronutrients | 1 kg |
| Indian paasi (Sargassum) | Growth stimulant, micronutrients | 1 kg |
| Water | Extraction medium | 50 L |

***Table 58 Application and process parameters: Kadal paasi thiravam***

| Parameter | Range in practice |
|---|---|
| Batch size | ~50 g to 1 kg seaweed mixed with 50 L water |
| Fermentation duration | No fermentation, brief pre-boiling |
| Stirring needs | Mixing during preparation |
| Application method | Foliar spray or root drenching |
| Dilution needs (if any) | ~100–200 ml per 10 L spray tank |
| Dosage / Volume per acre | 10-15 tanks per acre |
| Timing / Frequency | Growth stage and appearance of pest |
| Shelf life | 2-6 months (washed and dry) |

### *Distinctive Innovations and Notable Observations*

- While nutrient supplement is often the key focus of the seaweed formulation, farmers indicate that the formulation is found to be an effective pest repellent.
- Farmer prefer foliar spray over drenching or fertigation as the concentration requirement will be much higher for soil application and the need for pest control is on the foliage.
- Availability of seaweed in the market is limited and the farmers are sourcing only through the training team.

### *Scientific literature*

Kappaphycus and Sargassum combinations in crops like mustard, saffron, paddy and pulses show consistent growth promotion, nutrient-use efficiency, and yield gains, especially when applied as seed treatment plus foliar sprays at key growth stages and during visible stress or pest incidence. Field trials confirm that seaweed extracts act as multi-functional inputs as they enhance nutrient uptake and soil health, trigger induced systemic resistance, and provide direct antimicrobial and antifeedant effects.

The available research base around seaweed extracts is now extensive and provides strong evidence that seaweed extracts act as biostimulants and bio-protectants, improving plant growth, yield, nutrient use efficiency, stress tolerance, and resistance to pests and diseases. Since most formal studies and publications use commercial products, it is desirable to study and document farmer prepared formulations. Table 59 gives the supporting literature along with their key findings and references.

*Table 59 Supporting literature: Kadal paasi thiravam*

| Farmer observation / function | Key relevant findings from literature | References |
|---|---|---|
| Promotes plant growth and vigour | Seaweed extracts consistently enhance plant growth, biomass and yield across crops via biostimulant effects. | (Ali et al., 2021; Craigie, 2011) |
| Increases yield and profitability | Field and meta-analytical evidence show average yield gains of ~15–40% and improved economic returns with seaweed fertilizers/biostimulants. | (Singh et al., 2025; Pei et al., 2024) |
| Foliar nutrient supplement; improves nutrient uptake | Seaweed biostimulants improve nutrient uptake and nutrient-use efficiency, especially when applied as foliar sprays with fertilizers. | (Boukhari et al., 2020; Singh et al., 2025) |
| Acts as bio-pesticide: induces resistance to pests and diseases | Seaweed extracts act as phytoelicitors, activating plant defense pathways and reducing biotic stress (pests and pathogens). | (Ali et al., 2021; Kumar et al., 2024) |
| Mitigates abiotic stress; improves resilience | Seaweed-based biostimulants enhance tolerance to drought, salinity and temperature through hormonal and antioxidant modulation. | (Mukherjee & Patel, 2019; Nanda et al., 2021) |
| Improves soil health and supports beneficial microbes | Seaweed extracts improve soil properties and stimulate beneficial soil microbiota, contributing to soil health and fertility. | (Singh et al., 2025; Nanda et al., 2021) |
| Indian-relevant red and brown seaweeds | Tropical red and brown seaweed extracts (including Kappaphycus and Sargassum) improve growth, yield, nutrient-use efficiency and soil enzymes. | (Singh et al., 2025; Gandhi et al., 2024) |

### 5.3.9 VellaVelan Pattai Karaisal

Vella Velanmaram Pattai Karaisal is a fermented botanical preparation made with the bark of Vella Velanmaram (White Acacia/Acacia leucophloea) as a key ingredient. It combines with various fruits, bio-enhancers, and fermentation substrates. This formulation is considered used as a multi-purpose bio-input targeting growth promotion, early flowering induction, and pest management. Only two farmers, both from Dindigul district have reported using this formulation.

While the formulation has very limited documentation, antimicrobial and several medicinal properties of ingredients like *Acacia leucophloea* and Terminalia chebula are scientifically validated. Fruits like banana and grapes are rich in sugar suitable for fermentation and the coconut flower add vitamins and hormone into the formulation. Farmers report dual benefits of early flowering induction and pest management during critical crop stages, though these specific claims require formal validation. The preparation represents an innovative integration of traditional ayurvedic antimicrobial knowledge with fermentation principles often used in organic farming.

### *Core Composition and Practices*

The core composition of formulation from both the farmers revealed a relatively standardized recipe with minor variations. Both farmers use a core set of ingredients which includes white acacia bark (10-20 kg), coconut kurumbai (5 kg), grapes (1 kg), kadukkai powder (200-250 gm), and optional additions like banana and paddy straw followed by fermentation. The preparation begins with 50L of water mixed with all ingredients, undergoes 5-15 days of daily stirring for fermentation followed by two step dilution for application. Table 60 below give the list of ingredients used along with their role and Table 61 gives other application parameters like fermentation period, frequency, etc.

***Table 60 Ingredients and their role: Vella velaan pattai karaisal***

| **Ingredient** | **Role / Function** | **Quantity – Range in practice** |
|---|---|---|
| Vella velam pattai (*Acacia leucophloea* bark) | Pest suppression / growth support | 10–20 kg |
| Coconut kurumbai | Nutritional additive | 5 kg |
| Kadukai (Terminalia chebula fruit powder) | Antimicrobial properties; pest deterrent | 200 g |
| Paddy Straw | Carbon source; microbial colonization support | 0-1 kg |
| Grapes | Fermentation substrate; micronutrients | 1 kg |
| Banana | Potassium source; fermentation enhancer | 0-1 seepu (~8-12 fruits) |
| Cow urine | Fermentation medium | ~20 L |
| Country sugar | Fermentation feed | 10 kg |
| Water | Fermentation medium | 50 L (First stage for fermentation) |
| Water | Ready to use concentrate | 150 L |
| Optional | | |
| Pirandai (Cissus quadrangularis) | Botanical additive | 5 kg |

***Table 61 Application and process parameters: Vella velaan pattai karaisal***

| **Parameter** | **Range in practice** |
|---|---|
| Batch size | 200 L |
| Fermentation duration | 5–15 days |
| Stirring needs | Daily stirring |
| Application method | Foliar spray (mist blower preferred) |
| Dilution needs (if any) | 70–500 ml per 10 L tank (depends on crop stage) |
| Dosage / Volume per acre | ~10–15 tanks per acre |
| Timing / Frequency | Flowering stage and pest management |
| Shelf life | Up to 6 months |

*Notable Observations and Innovations*

- The bark of Acacia is often used in production of countryside alcohol and farmers indicate that the formulation involves a similar fermentation process and role of alcohol in pest control.
- Similar to a few other formulations, farmer warn the strong vigour of the formulation and indicated the importance of appropriate dilution for sensitive crops and early-stage crops.
- This formulation was reported only by a niche of farmers from Dindigul district without any attribution to trainings or model farmers indicating a regional knowledge system which needs detailed studies and documentation.

*Scientific literature*

The distinctive strength of Vella Velanmaram Pattai Karaisal lies in how distinct ingredients contribute complementary functions like tannin/phenolic-rich barks and fruits for antimicrobial and deterrent effects, and coconut inflorescence sap and paddy straw as nutrient-rich, microbially active fermentation and biostimulant substrates.

Acacia leucophloea bark is rich in polyphenols, flavonoids, tannins and other secondary metabolites with documented antimicrobial and insecticidal activities, provides a bioactive base. Studies also show unfermented sap and sap-based additives can enhance somatic embryogenesis, pointing to hormone- and signal-like effects on plant cells. Paddy straw provides a lignocellulosic carbon source but there is a dearth of direct studies on its use as substrate for fermentation. While strong indirect scientific support could be found for most of the underlying principles, there is no direct experimental evidence yet for the specific combination. Table 62 gives the supporting literature along with key findings and references.

***Table 62 Supporting literature: Vella velaan pattai karaisal***

| Farmer observation / function | Key relevant findings from literature | References |
|---|---|---|
| Tannin-rich bark as general antimicrobial resource | Bibliometric review highlights tannin-rich bark (Fabaceae, Terminalia spp.) as a major source of antimicrobial bioactives, supporting use of such barks in protective formulations. | (Ucella-Filho et al., 2022) |
| Synergy with antibiotics (Terminalia) | Extracts of T. chebula (and related Terminalia) enhance activity of several antibiotics against resistant bacteria, showing additive/synergistic interactions. | (Tiwana et al., 2024; Thakar, 2025) |
| Fermentable, nutrient-rich medium (coconut inflorescence sap) | Fresh sap is rich in sugars, amino acids, minerals, phenolic acids, flavonoids and vitamins, and remains non-alcoholic when chilled. | (Hebbar et al., 2020; Sharafudeen et al., 2022) |
| Plant-growth / morphogenesis support (coconut sap) | Unfermented coconut inflorescence sap added to culture media markedly enhances | (R., 2025) |

| | | |
|---|---|---|
| | embryogenic callus induction and somatic embryo maturation in coconut. | |
| Endophytic microbiome (Terminalia chebula) | T. chebula tissues host diverse endophytic fungi producing alkaloids, flavonoids, phenols, terpenoids and tannins with strong antimicrobial activity. | (Sakshi & Mohanka, 2024) |
| Broad phytochemical base (Acacia spp.) | Acacia genus provides flavonoids, tannins, alkaloids, gums and other bioactives with multiple pharmacological activities relevant to health and protection. | (Batiha et al., 2022; Tiwari et al., 2023) |

### 5.3.10 Vasambu Karaisal (Sweet Flag/Calamus Extract)

Vasambu Karaisal is a fermented botanical preparation made primarily from Vasambu (Acorus calamus - Sweet Flag), a rhizomatous plant highly valued in traditional medicine. Many studies indicate a range of pharmacological properties like insecticidal, larvicidal, antibacterial, mutagenic, cytotoxic, etc. and a few studies have focussed on agricultural application illustrating disease and pest control properties of sweet flag. This formulation is often used as a seed treatment agent for pest management. While one farmer has applied it as an exclusive formulation with diverse ingredient, two farmers have used sweet flag as an ingredient in other formulations like Jeevamirtham or botanical extracts, and another farmer use the powder form around the stored grains.

Vasambu Karaisal serves multiple functions with the boutique of ingredients with different characteristics. The sweet flag rhizome contains essential oils rich in β-asarone, α-asarone, and other terpenoids that exhibit insecticidal and properties. When fermented with complementary ingredients like turmeric (antimicrobial), sunnambu/lime (pH adjustment and calcium source), cow urine (nitrogen and microbial inoculant), camphor (volatile pest deterrent), and neem oil (azadirachtin for pest control), the preparation creates a synergistic bio-active solution. Traditional knowledge systems have long recognized Vasambu's protective properties and it was historically used to protect stored grains. Modern organic farmers have adapted this traditional knowledge into fermented extracts for field crop protection.

#### *Core Composition and Practices*

The preparation process for Vasambu karaisal involves soaking 500 gm of Vasambu rhizome in water, grinding it to a paste, and then mixing it with turmeric powder, slaked lime, cow urine, camphor, and neem oil to form a homogeneous solution. No fermentation is required and the mixture is used immediate or within the same day of preparation. In an alternative protocol by a farmer, vasambu is used along with neem, Vitex negundo, and dried chilli. Overall, these protocols emphasise multi-ingredient synergy for protection from pests. Table 63 below give the list of ingredients used along with their role and Table 64 gives other application parameters like fermentation period, frequency, etc.

*Table 63 Ingredients and their role: Vasambu karaisal*

| Ingredient | Role / Function | Range in practice |
|---|---|---|
| Vasambu (Sweet flag rhizome) | Pest repellent | 0.5 kg |
| Turmeric powder | Antimicrobial / disease suppression | 50 g |
| Sunnambu (slaked lime) | pH adjustment; protective role | 5 g |
| Cow urine (Gomutram) | Extraction medium; microbial activity | 0.5 L (500 ml) |
| Camphor | Volatile pest repellent | 50 g |
| Neem oil | Pest suppression | 50 ml |
| Water | Carrier medium | 20 L |

*Table 64 Application and process parameters: Vasambu karaisal*

| Parameter | Range in practice |
|---|---|
| Batch size | 20L |
| Fermentation duration | Soaking period |
| Stirring needs | Mixing during preparation |
| Application method | Foliar spray |
| Dilution needs (if any) | Diluted in spray tank |
| Dosage / Volume per acre | Not specified |
| Timing / Frequency | Pest management application |
| Shelf life | Immediate consumption |

### *Notable Observations and Innovations*

- The formulation not only uses traditional ingredients but the innovation of sophisticated synergy of combining multiple protective agents needs detailed analysis.
- This formulation was reported only by a niche of farmers indicating the need for detailed studies and documentation.
- The emphasis of the formulation is for its application in seed treatment.
- Vasambu Karaisal reflects a sophisticated farmer-led integration of botanical insecticides, cow-urine–based extracts, and traditional seed/grain protection into a single practice. A. calamus extracts are potent bioinsecticides more broadly: methanolic or crude extracts and isolated compounds show high toxicity or strong feeding inhibition against mites, lepidopteran larvae and other insects.
- The available research strongly supports key components of Vasambu Karaisal, but does not yet test the exact farmer-designed formulation or its seed-treatment protocol in field crops. Surveys in Tamil Nadu, Rajasthan, Assam, Nagaland and hill regions show dozens of rational, scientist-validated indigenous pest management practices using neem, Vitex, chilli, cow urine, lime and other botanicals, often judged effective, low-cost and environmentally safe. However precise formulations, dose–response trials and long-term field data are limited.

### *Scientific literature*

Vasambu Karaisal reflects a sophisticated farmer-led integration of botanical insecticides, cow-urine–based extracts, and traditional seed/grain protection into a single practice. A. calamus extracts are potent bioinsecticides more broadly: methanolic or crude extracts and isolated compounds show high toxicity or strong feeding inhibition against mites, lepidopteran larvae and other insects.

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***Table 65 Supporting literature: Vasambu karaisal***

| **Farmer observation / function** | **Key relevant findings from literature** | **References** |
|---|---|---|
| Vasambu seed treatment improves germination and vigour | Acorus calamus rhizome powders protect mungbean from cowpea weevil without reducing seed germination or vigour, supporting its use as a seed-safe protectant. | (Dhimal & Kinley, 2023) |
| Vasambu powder protects stored grains from insects | A. calamus rhizome powder is highly effective against cowpea weevil in stored mungbean, preventing progeny and weight loss. | (Keerthika & Niranjana, 2023; Dhimal & Kinley, 2023) |
| Vasambu-based sprays act as insecticidal/acaricidal agents in the field | Sweet flag rhizome extracts cause up to ~97% reduction of the mite Tetranychus truncatus on cucumber. A. calamus essential oil is strongly insecticidal, repellent and feeding-deterrent to major stored-grain beetles. | (Chandrabhanu et al., 2025; Wijerathna et al., 2023) |
| Broad antimicrobial / pesticidal protection from vasambu | Essential oils from A. calamus rhizomes are rich in β-asarone and show strong nematicidal, insecticidal and herbicidal activity, with dose-dependent effects (Joshi et al., 2023). | (Joshi et al., 2023) |

### 5.3.11 Physical traps

Physical traps represent non-chemical, mechanical pest management tools often used in organic farming systems. These devices capture or monitor insect pests through visual attraction (color), chemical attraction (pheromones), or light attraction, providing continuous pest control without toxic residues. Physical traps serve multiple functions in pest management that includes monitoring pest populations to determine presence, density, and economic threshold levels, mass trapping to reduce pest populations below economically damaging levels and early warning systems to trigger timely intervention with complementary control measures. While 5 farmers (11% of sample) reported to use sticky traps and/or pheromone traps, one farmer (2% of sample) reported the use of light trap.

### *Core Composition and Practices*

Installation and maintenance of pest traps typically involve procuring either commercial or homemade sticky and pheromone traps, with farmers in Tamil Nadu often improvising by using only lures with plastic bottles due to limited availability of complete systems. Traps are strategically placed throughout the field which was recommended as 16 traps per acre by one of the farmers at appropriate height to ensure optimal pest control and monitoring. Table 66 gives details about the application parameters of various physical traps.

***Table 66 Application parameters: Physical traps***

| Parameter | Sticky Traps | Pheromone Traps | Light Traps |
|---|---|---|---|
| Trap Density | 16 traps/acre | 16 traps/acre (Jacob farm) | Not specified |
| Target Specificity | Broad spectrum by color | Species-specific by pheromone | Broad spectrum nocturnal |
| Installation Timing | Preventive at crop establishment | Early season before pest buildup | Not documented |
| Commercial Availability | Moderate availability | Poor availability | Adhoc method |

### *Notable observations and practices*

- While no challenges were reported by farmers on the availability of sticky traps, pheromone traps are very difficult to find in the market.
- Traps are usually used more like an additional pest control measure or to understand the pest level rather than pest control measure by itself.
- The explicit use of yellow, blue, and white traps with targeted approach demonstrates advanced understanding of pest behavior and color preferences. While yellow trap is used for aphids, whiteflies, leaf miners, blue is used for thrips and white is used for beetles and bugs.

### *Scientific literature*

Reviews emphasize sticky, pheromone and light traps as key components of eco-friendly, non-chemical pest management, reducing insecticide dependence and supporting organic/IPM systems. Sticky and colour traps are used for monitoring and reducing pest populations where yellow traps attract whiteflies, aphids and other sap-suckers; blue traps capture thrips at high levels; and non-yellow colors (green, white or others) can preferentially catch leafhoppers and some beetles. Pheromone traps are effective for lepidopteran pest control but face adoption challenges due to supply and understanding issues, while light traps, especially solar and LED variants, attract nocturnal pests but require careful use to minimise ecological risks.

Experiments across Asia and beyond consistently show that color, pheromone and light traps can monitor key pests, trigger timely interventions, and sometimes achieve mass trapping and yield gains when deployed at sufficient density and with appropriate designs. Table 67 gives the supporting literature along with the key findings and references.

***Table 67 Supporting literature: Physical traps***

| Farmer observation / function | Key relevant findings from literature | References |
|---|---|---|
| Traps used mainly to "understand pest levels" and plan other actions | Traps (sticky, pheromone, light) are described as decision-support tools to estimate pest presence, abundance and dynamics for IPM decisions. | (Preti et al., 2020; Murtaza et al., 2019) |
| Yellow traps for aphids, whiteflies, leaf miners | Yellow sticky traps strongly attract whiteflies, aphids and other sap-sucking pests. | (Nagaraj et al., 2025; Murtaza et al., 2019) |
| Blue traps for thrips | Blue sticky traps capture thrips more efficiently than yellow or other colors in field and protected crops. | (Murtaza et al., 2019; Houjun et al., 2021) |
| White / non-yellow traps for beetles and bugs | Trap color and surface strongly affect species caught; non-yellow plates are used to target broader insect groups, including beetles, in multi-source trap designs. | (Houjun et al., 2021; Zeng et al., 2025) |
| Use of ~16 traps/acre (sticky / pheromone) | Trap efficacy depends on layout density and spacing; optimization studies indicate multiple traps per ha are needed for effective monitoring/mass trapping. | (Guimapi et al., 2019; Houjun et al., 2021) |
| Light traps as broad-spectrum nocturnal control, supplementary to other measures | Light traps attract moths, flies and beetles and are effective non-chemical tools, but must be integrated with other IPM components and used with ecological safeguards. | (Basu, 2025; Kim et al., 2019) |

### 5.3.12 Veppankottai Karaisal (Neem Seed Extract)

Veppankottai Karaisal represents a neem seed-based pest control formulation that utilizes the concentrated pesticidal compounds found in neem seeds, particularly azadirachtin, which is present in higher concentrations in seeds compared to neem leaves. With 3 farmers (6% of the sample) implementing this practice, this formulation was used by one farmer each from Tiruppur, Pudhukottai and Dindigul.

The formulation works through the multiple mechanisms associated with neem compounds, functioning as both a preventive measure applied before pest establishment and as a curative treatment for existing infestations. Farmers report effectiveness against a range of sucking and chewing insects, with applications timed strategically during vulnerable crop stages or in response to pest monitoring results.

Farmers implementing this practice recognize neem seeds as more concentrated sources of pest control compounds compared to readily available neem leaves, positioning Veppankottai Karaisal as an intensive intervention for pest situations requiring stronger action than standard leaf-based formulations can provide.

### *Core practice and diversity*

The core composition of Veppankottai Karaisal formulations shows consistency in basic structure among the documented farmers. The standard preparation methodology involves grinding neem seeds into powder or crushing them coarsely to increase surface area for extraction. One method involves tying the crushed seeds in cloth and submerging in cow urine, while another involves mixing ground seed powder directly into the cow urine. The mixture soaks for 24-48 hours with occasional stirring to enhance extraction of oil-soluble azadirachtin and other compounds into the cow urine medium.

After soaking, the mixture is strained thoroughly through cloth to remove solid particles that could clog spray equipment. The concentrate is diluted at approximately 1 liter per 10-liter spray tank (1:10 ratio) for field application, with coverage typically requiring 8-10 tanks per acre. Table 68 below give the list of ingredients used along with their role and Table 69 gives other application parameters like fermentation period, frequency, etc.

***Table 68 Ingredients and their role: Veppankottai karaisal***

| Ingredient | Role / Function | Range in practice |
|---|---|---|
| Neem seeds | Pest control | 1-5 kg |
| Garlic | Enhancement | 1–2 kg |
| Cow urine | Extraction medium | 10 L |

***Table 69 Application and process parameters: Veppankottai karaisal***

| Parameter | Range in practice |
|---|---|
| Batch size | 1–5 kg neem seed with garlic and gomutram (10–20 L) |
| Fermentation duration | 24–48 hrs soaking |
| Stirring needs | Occasional mixing |
| Application method | Foliar spray |
| Dilution needs (if any) | Around 1 L extract per 10 L spray tank (varies) |
| Dosage / Volume per acre | ~8–10 spray tanks per acre |
| Timing / Frequency | Preventive or at early pest incidence |
| Shelf life | Immediate use |

### *Distinctive Innovations and Notable Observations*

- While Kumar from Pudhukottai, indicates the usage of the formulation as a preventive pest control practice, Kuzhandhaivel from Dindigul uses the formulation specifically for pulses crop.
- While neem leave are more prominent in pest management practices under organic farming, use of neem seed is relatively less and often constrained due to availability as well as cost.

*Scientific literature*

Neem seeds are the most azadirachtin-rich part of the tree and therefore the most potent for insect control compared with leaves or other tissues. Azadirachtin and related limonoids in neem seed/kernel extracts act as antifeedants, insect growth regulators, sterilants and repellents, with broad activity against hemipteran (sucking) and lepidopteran (chewing) pests and relatively low toxicity to natural enemies and mammals.

There is strong and long-standing evidence that neem seed–derived products (seed kernel extract, seed oil, commercial azadirachtin formulations) are effective, broad-spectrum, relatively safe biopesticides. While the core logic and most functional claims of Veppankottai Karaisal are well supported by the broader neem biopesticide literature, specific formulation and use of cow urine needs to be studied. Table 70 gives the supporting literature along with key findings and references.

***Table 70 Supporting literature: Veppankottai karaisal***

| Farmer observation / function | Key relevant findings from literature | References |
|---|---|---|
| Neem seeds are more concentrated and potent than leaves | Seed kernels are the principal source of azadirachtin; seed-based products are far more bioactive than leaf extracts for pest control. | (Gahukar, 2014) |
| Controls a range of sucking and chewing pests (both preventive and curative spray) | Neem phytochemicals act as antifeedants, growth regulators and repellents against many sucking and chewing insect pests on field crops. | (Gahukar, 2014) |
| Mainly reduces feeding and reproduction, not just kills insects outright | Azadirachtin interferes with feeding, molting, oviposition and fitness, often lowering damage and reproduction more than visible mortality. | (Chaudhary et al., 2017) |
| Seed-based formulations are preferred when pest pressure is high or leaf extracts are insufficient | Reviews emphasize higher azadirachtin content and stronger bioefficacy of seed-derived products, recommending them over leaf extracts for difficult infestations. | (Gahukar, 2014, Adusei & Azupio, 2022) |
| Simple on-farm soaking of ground seeds, followed by dilution and foliar spraying | Traditional and farmer-level preparations using crushed seeds in water are widely reported as practical and effective low-input neem technologies. | (Verma et al., 2021, Meenaa et al., 2021) |
| Extract should be used fresh; short shelf life in village conditions | Azadirachtin content and bioefficacy in crude extracts decline rapidly with storage, high temperature and sunlight, supporting use of fresh sprays. | (Gahukar, 2014) |

# 6. Science-Practice Integration

The practices documented in this study demonstrate that agro-ecological innovation often emerges through iterative field experimentation, observation, and peer exchange among farmers. Many formulations reflect sophisticated understandings of soil microbiology, fermentation, ecological pest regulation, and nutrient cycling, even when these understandings are expressed through experiential rather than academic learning. Through a grounds-up knowledge synthesis process, the present section recognises the scientific research as one pathway of validation, farmer practice as an active experimental process, and agro-ecological knowledge system as evolving through interaction between both systems. Rather than treating absence of direct scientific studies as absence of validity, this synthesis distinguishes between different levels of evidence maturity, acknowledging that innovation frequently precedes formal research documentation.

## 6.1 Emerging Patterns Across Practices

The review of practices by the farmers reveals four important patterns across 30+ practices documented across Tamil Nadu as follows

1. **Core ecological mechanisms are frequently well supported -** Processes such as microbial fermentation, botanical pest deterrence, nitrogen fixation, and organic matter transformation are widely validated in scientific literature.
2. **Formulation-level validation is often lacking -** While ingredients or principles are scientifically recognised, the exact farmer-developed combinations, ratios, and preparation processes have rarely been examined through controlled field studies.
3. **Farmers frequently extend beyond existing research -** Innovations such as novel ferment combinations, ingredient substitutions, and locally adapted preparation methods reflect ongoing experimentation that science has not yet systematically captured.
4. **The primary gap is not conceptual but methodological -** Research needs on dosage requirements, safety thresholds, shelf-life, quality indicators, and context-specific performance rather than proving basic reasoning.

## 6.2 Science-Practice Matrix

We build a science-practice matrix to bridge practice-derived knowledge and formal scientific literature, supporting cross-learning among farmers, researchers, extension systems, and policymakers. It strives to identify areas where farming practices are aligned with scientifically proven mechanisms and evidence, highlight instances in which individual components have been studied while the farmer-designed formulations themselves are still insufficiently documented, and flag significant research gaps where robust field-level practices persist despite limited formal scientific scrutiny. In order to provide a foundation for future participatory validation and collaborative experimentation, each practice is positioned using the following evidence metric

- **Strong and robust:** Replicated field trials, meta-analyses, or synthesis-level studies directly supporting the practice or closely comparable protocols.
- **Moderate, limited field studies:** Strong and direct component-level evidence with some or limited field validation of similar formulations or approaches.
- **Weak, indirect evidence:** Moderate or indirect evidence supporting individual ingredients or mechanisms, but little or no direct testing of the integrated practice.
- **Marginal, Practice-led:** Limited or indirect scientific evidence; the practice remains primarily supported by farmer observation and experiential experimentation.

This framework should be interpreted as indicating degree of formal documentation, not inherent effectiveness or reliability of a practice. By documenting where farmer knowledge aligns with, extends beyond, or remains outside existing literature, this section reinforces a key contribution of the study on state of organic farming in Tamil Nadu. The following Tables 71 and 72 give an overview of the current evidence landscape across the documented agro-ecological practices, highlighting varying levels of scientific documentation and research maturity. Each practice note therefore serves as a focused bridge between field-generated knowledge and formal science, enabling us to understand not only the level of evidence available but also the nature of the gaps and opportunities for future collaborative validation.

Many formulations classified as “weak” or “marginal, practice-led” are grounded in well-established ecological principles such as microbial fermentation or botanical pesticidal activity but lack direct field trials evaluating the exact farmer-developed combinations, preparation protocols, or context-specific adaptations. This reflects a broader pattern in agro-ecological innovation, where field experimentation and practice by farmers often precedes formal research attention. In several cases, farmers appear to be extending or recombining scientifically recognized mechanisms in ways that have not yet entered mainstream agronomic research frameworks.

*Table 71 Soil nutrient management practices*

| Practice / Formulation | Purpose | Evidence/Documentation level | Nature of Evidence | Specific Attention Needs |
|---|---|---|---|---|
| Green Manuring | Soil carbon, N cycling, structure | Strong and robust | Reviews + long-term field studies + syntheses | Local species optimisation; transition-stage protocols |
| Jeevamritam / Amirdhakaraisal | Microbial inoculation & nutrient mobilization | Moderate, limited field studies | Direct formulation studies + microbial analysis | Application frequency; microbial viability |
| Panchagavyam | Growth stimulant | Moderate, limited field studies | Multiple crop trials but limited long-term data | Standardisation, long-term soil impacts |
| Meenamilam (Fish amino acid) | Rapid growth, amino-N source | Moderate, limited field studies | Strong fish fertilizer evidence; limited direct TN protocol trials | Dose–response, shelf-life |
| Enriched Compost | Soil health & nutrient stabilization | Strong and robust | Multi-location field trials; microbial compost research | Inoculant standards; maturity indicators |
| EM Karaisal | Soil microbial activation | Moderate, limited field studies | Extensive literature on EM consortia globally; No studies on locally adapted EM preparations | TN-specific performance trials, microbial survival and compatibility studies. |
| Ghanajeevamritam | Solid microbial input | Weak, indirect evidences | Related compost inoculant research | Comparative trials with FYM and jeevamirtham |
| Saani Paasi Karaisal (cyanobacterial) | Biological N and soil conditioning | Moderate, limited field studies | Cyanobacteria evidence strong; formulation-specific evidence limited | Strain characterization; persistence |
| Beejamritham | Seed treatment, early-stage protection, microbial coating | Moderate, limited field studies | Strong conceptual basis in seed biopriming and microbial seed coating literature; limited direct trials of traditional Beejamritham. | Comparative germination trials; pathogen suppression assessment |
| Perungaya Karaisal (Asafoetida) | Repellent & antimicrobial | Weak, indirect evidence | Lab phytochemical studies | Field efficacy trials |
| Vasambu seed treatment | Storage & seed protection | Moderate, limited field studies | Storage pest studies | Field crop validation |
| Ash treatments | Seed safety | Weak, indirect evidence | Traditional studies, limited direct trials | Germination impact analysis |

*Table 72 Pest & Disease Management Practices*

| Practice / Formulation | Farmer Intention | Evidence/Documentation level | Nature of Evidence | Specific Attention Needs |
|---|---|---|---|---|
| Poochiveratti (multi-leaf ferment) | Broad pest regulation | Weak, indirect evidence | Botanical fermentation evidence | Ingredient and dose standardization, pest specific field studies |
| Punnaku karaisal | Multi-botanical control | Weak, indirect evidence | Botanical pesticide literature | Field effectiveness as formulation in the field |
| Moor Karaisal / Theimoor Karaisal (buttermilk ferment) | Disease suppression, growth | Weak, indirect evidence | LAB & buttermilk studies; limited named formulation evidence | Standard recipe testing |
| Agnihastram | Strong botanical pesticide | Weak, indirect evidence | Components highly studied; mixture under-tested | Field validation |
| Karpoora Karaisal (Camphor-based formulation) | Repellent action against sucking pests and storage pests | Marginal, Practice-led | Camphor and related terpenoids are documented as insect repellents but limited agricultural field trials | Field efficacy validation, phytotoxicity thresholds |
| 3G Karaisal (Ginger-Garlic-Green chilli extracts) | Deterrence | Moderate, limited field studies | Botanical insecticide evidence | Formulation based field experiment and synergy testing |
| Ennai Karaisal (Oil-based botanical formulation) | Suffocation control of soft-bodied insects | Moderate, limited field studies | Botanical oil sprays widely studied for pest control; limited studies on farmer-specific oil mixtures | Emulsification stability; leaf-surface persistence; compatibility with other botanical extracts. |
| Kadal Pasi Thiravam (Seaweed extract liquid) | Growth promotion and stress tolerance | Moderate, limited field studies | Extensive global research on seaweed extracts as plant biostimulants; no studies on pest and diseases suppression | Testing of farmer-prepared extracts and dosage standardization |
| Vella Vellan Pattai Karaisal | Foliar diseases and sucking pests) | Marginal, Practice-led | Scientific literature supports antimicrobial and pesticidal properties of tannin-rich bark extracts | Field-level validation of formulation efficacy |

| | | | | |
|---|---|---|---|---|
| Vasambu Karaisal (Acorus calamus) | Seed and field pest management | Marginal, Practice-led | Strong component evidence + limited field validation | Direct formulation trials |
| Veppankottai Karaisal (Neem seed extract) | Pest control | Strong and robust | Extensive botanical pesticide evidence | Local extraction protocols |
| Sticky traps | Monitoring & suppression | Strong and robust | Established IPM evidence | Local threshold calibration |
| Pheromone traps | Species monitoring | Strong and robust | Well-established IPM literature | Trap density optimisation |
| Light traps | Night pest control | Moderate, limited field studies | Documented efficacy; ecological concerns | Non-target impact studies |

## 6.3 Interpreting the Knowledge Gap

The evidence landscape suggests that organic farming in Tamil Nadu is characterised by a dynamic where practice innovation often outpaces formal scientific validation. Many widely adopted practices occupy a space where farmer experience demonstrates perceived reliability, but structured research remains limited or fragmented.

To better understand the relationship between farmer innovation and formal scientific validation, the documented practices were grouped according to the strength and nature of available scientific literature. The resulting Practice-Science Matrix given below maps the current state of research documentation of 27 practices analysed along with their implication and priority areas to advance the agro-ecological knowledge system.

| Evidence Category | Scientific Literature | Implication for Scaling | Priority Action |
|---|---|---|---|
| **Strong and robust** (Green Manuring, Enriched Compost, Neem-based formulations, Physical traps) (5/27) | Multi-location field trials; long-term soil and yield studies; replicated agronomic research | Scientifically robust; ready for wider promotion with contextual adaptation | Dissemination, farmer training, district-level demonstration plots |
| **Moderate, limited field studies** (Jeevamirtham, Panchagavyam, Meenamilam, EM karaisal) (12/27) | Some field studies + microbiological or crop-level experimental validation | Widely practiced; evidence supports ecological logic but lacks long-term studies | Multi-season field trials and impact characterisation |
| **Weak, indirect evidence** (Poochiveratti, Agnihastra, 3G karaisal, etc.) (7/27) | Studies validate ingredients (e.g., garlic, chilli, vitex. etc.) but limited trials on full formulation | Ecologically sound; practice-rich but under-tested as composite formulations | Controlled field bioassays; synergy studies; pest–crop specificity trials |
| **Marginal, Practice-led** (Vella Velan pattai karaisal, Karpura karaisal, etc.) (3/27) | Limited or no direct trials; mostly experiential knowledge | Innovation space; constrained by lack of formal documentation | Participatory research and practice documentation |

A deeper examination of the documented practices reveals that differential levels of scientific validation between nutrient management and pest management systems. This indicates a significant asymmetry in the risk environment within which these practices operate. Nutrient management practices such as green manuring, compost enrichment and microbial ferments, generally influence crop performance through gradual soil-mediated processes. While suboptimal nutrient strategies may reduce yield or plant vigour, their effects are typically incremental and buffered by residual soil fertility or previous management practices. This creates a relatively lower livelihood shock and allows farmers some degree of experimentation and adaptive learning.

In contrast, pest and disease outbreaks often represent acute, high-stakes events. By the time an infestation becomes visible, farmers have often already invested substantially in land preparation, seed, irrigation, labour, and other inputs. Crop loss at this stage can be rapid and severe, with limited scope for recovery. For small and marginal farmers in particular, such losses can directly threaten repayment capacity, household consumption stability, and long-term economic viability. Pest and disease management therefore operates within a compressed decision window where uncertainty carries disproportionately high consequences.

This differential risk architecture has important implications for interpreting the evidence landscape documented in this report. While nutrient management practices tend to show stronger alignment with existing scientific literature, pest and disease management formulations frequently fall into categories of weak and indirect evidence or marginal, farmer led categories despite high farmer adoption. This reflects a dearth in research investment focusing on practices catering to high-risk and critical situations. For example, multi-component botanical and ecological pest management formulation like poochiveratti which is widely adopted have received very limited systematic documentation.

Hence, farmers adopting organic systems are working with formulations and strategies that are experientially refined, ecologically coherent, and often effective in routine conditions. A stronger and more responsive research around ecological pest and disease management will complement scaling up of organic farming with a robust knowledge support system. Such a supportive knowledge ecosystem would enhance farmer confidence, expand the range of conceptually grounded options available during crisis situations, and reduce livelihood exposure. More importantly, it would reposition research institutions as collaborative partners in strengthening ecological resilience. By investing in structured, iterative farmer–scientist engagement around pest and disease management, the transition to organic farming can shift from individual risk-bearing experimentation toward collectively supported, knowledge-rich scaling.

# 7. Conclusion and Way Ahead

This Phase 1 report on the State of Organic Farming in Tamil Nadu demonstrate that organic farming in Tamil Nadu is a vibrant, knowledge-rich ecosystem shaped by decades of farmer innovation, experimentation, and adaptive learning. The diversity of formulations, adaptive ingredient substitutions, district-level variations, and integration of microbial and botanical principles reveal a deeply ecological and social approach to farm management.

Seven distinct operational models were identified across the state ranging from collective and cooperative initiatives to value-addition-driven direct marketing, trainer-led farms, allied service models, lifestyle-oriented self-reliant farms, and transition-phase “search for light” farmers. These operational designs demonstrate that agro-ecological transition is not uniform; it unfolds through diverse livelihood pathways shaped by market access, risk appetite, resource endowment, and social networks. While some farmers have built robust collective markets and self-reliant input systems, others remain isolated in transitional spaces practicing agro-ecology without adequate market recognition or institutional support.

The knowledge synthesis represents a foundational shift by positioning experienced farmers as the primary knowledge sources, systematically documenting their practice, and creating a foundation for subsequent cross-learning. The comprehensive documentation of 30+ practices, each with detailed protocols, variations, and innovations, creates a highly valuable and practically relevant resource for cross-learning among farmers. Supported by peer reviewed publications, the report identifies the areas where farmer knowledge aligns with, extends beyond, or contradicts formal scientific understanding, thereby highlighting critical research gaps and opportunities for collaborative farmer-scientist innovation.

The Science–Practice Matrix demonstrates that while several soil nutrient management practices are supported by robust scientific literature, many pest and disease management formulations represent active frontiers of farmer-led innovation. Pest and disease management practices operate within a higher-risk decision environment where farmer livelihoods are acutely exposed. The relative lag in formal validation of ecological pest management systems therefore represents not only a knowledge gap but a structural vulnerability with direct livelihood implications, requiring urgent participatory research and institutional support. Research prioritisation needs to focus on ecological pest management systems for de-risking the farmers with enhanced knowledge ecosystem for transitioning into agro-ecological practices.

Further, the report highlights the productive opportunities at both the end of knowledge and practice rather than a deficit. While scientific literature provides farmers with detailed and peer-validated protocols for cross-learning; practices with high farmer adoption but limited documentation represents valuable, field-tested hypotheses emerging from real-world experimentation. They offer a strong foundation for participatory trials, field studies, and protocol refinement. Strengthening structured dialogue between farmer innovation and scientific inquiry can transform localized experiential successes into widely accessible agro-ecological knowledge while preserving the adaptive, context-sensitive character that defines organic farming systems.

Thus, systematic documentation of farmer-led practice is not an endpoint, but the institutional starting point for a collaborative and iterative knowledge-building process between farmers, researchers, and policy systems. Extending similar state-level practice documentation and evidence mapping across other regions of India would create a national baseline of agro-ecological practice maturity, helping identify high-risk knowledge gaps, align research investment with field realities, and design differentiated institutional support systems. Further, the report makes it clear that the farmers are not passive adopters of techniques and they are active system designers navigating ecological, economic, and social realities. Institutional support must therefore move beyond technology promotion toward enabling differentiated pathways of adoption, de-risking high-stakes decisions, and building a robust knowledge ecosystem that sustains both ecological integrity and farmer confidence.

# Annexure 1: Compilation of typology of agro-ecological practices in India

| Name | Location | Description | Key principles | Distinct practice | Timeline |
|---|---|---|---|---|---|
| Aavartansheel Kheti | Uttar Pradesh | Circularity and balance with co-existence as the key idea. | 5 internalised cycles including water, nutrient, energy, labour and seeds/microbes. | Farm pond to start with and post harvest processing or value addition is mandatory component of the farm. | Modern |
| Agroforestry | Pan-India | Integrates trees and crops/livestock for ecological and economic benefits. | Integrates trees with crops and livestock. | Alley cropping, silvopasture (grazing under trees), home gardens, and shelterbelts. | Modern |
| Alder-Based Farming | Nagaland | Practiced by the Angami tribe, where alder trees are used in Jhum fields to fix nitrogen and restore soil fertility. | Soil fertility enhancement using nitrogen-fixing trees. | Planting alder trees (Alnus spp.) in shifting cultivation areas to improve soil fertility and reduce soil erosion. | Traditional |
| Amrut Krishi | Maharashtra and Gujarat | A natural farming method using Amrut Mitti (living soil) and Amrut Jal (natural fertilizer). | Focus on preparing "Amrut Mitti" (living soil) and "Amrut Jal" (natural liquid fertilizer). | Combining cow dung, urine, jaggery, and water to create bio-fertilizers. | Traditional |
| Annapurna Krishi | Central and Northern India (Madhya Pradesh, Uttar Pradesh, Bihar). | Holistic farming emphasizing food security and diverse cropping systems. | Holistic farming approach to enhance soil nutrition and food security. | Use of natural soil amendments, multi-cropping, and seasonal rotations. | Modern |
| Apatanis | Arunachal Pradesh | Indigenous farming by the Apatani tribe, combining fish rearing with rice cultivation in terraced fields. | Integrated fish-rice farming. | Terrace farming with rice and fish in wetlands. | Traditional |

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|---|---|---|---|---|---|
| Bagar Farming | Uttar Pradesh | Traditional farming in floodplains using residual moisture for crops. | Farming in floodplains using residual moisture. | Cultivating crops like pulses, wheat, and vegetables on riverbanks after the floodwaters recede. | Traditional |
| Baranaja | Uttarakhand (Himalayan region) | A mixed-cropping system involving 12 or more crops grown together, enhancing biodiversity and resilience. | Diversity-based multicropping for food security. | Growing 12 or more crops in one field (e.g., cereals, pulses, and vegetables). | Traditional |
| Bari Agroforestry System | Assam | Home gardens (bari) with crops like areca nut, betel leaf, black pepper, and banana intercropped with vegetables. | Multi-tier farming near homes in Assam and other Northeastern states. | Combining areca nut, betel leaf, banana, and black pepper with vegetables. | Traditional |
| Bari Cultivation | Madhya Pradesh | Traditional terrace farming method in hilly regions of Madhya Pradesh | Home garden agroforestry system. | Growing diverse crops (vegetables, spices, fruits) around homes with organic inputs and water management. | Traditional |
| Beda/Bonda farming | Odisha | Traditional tribal farming system in Odisha. | | Combining shifting cultivation with stable cropping around forest fringes. | Traditional |
| Beushening | Eastern India (Odisha, West Bengal) | A traditional practice of manual weeding and soil loosening for better crop growth. | Traditional weeding and soil loosening | Manual labor for better soil aeration. | Traditional |
| Bhartiya Prakritik Krishi Paddhati | Pan-India | Government-promoted chemical-free farming method based on natural inputs | | Emphasis on cow-based inputs, bio-fertilizers, and pest control using indigenous solutions. | Modern |

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|---|---|---|---|---|---|
| Bhitora System | Chhattisgarh | A rain-fed farming system combining crop cultivation with natural resources conservation. | Rain-fed farming in Chhattisgarh. | Soil moisture conservation and mixed cropping. | Traditional |
| Bhungroo Irrigation Farming | Gujarat, used in water-scarce regions. | | Harvesting and storing rainwater underground to irrigate during dry spells. | Utilizing specially designed underground boreholes to store excess rainwater. | Modern |
| Biodynamic Farming | Maharashtra, Tamil Nadu, Himachal Pradesh | A spiritual-ecological approach using cosmic rhythms and organic practices. | Holistic farming with spiritual and cosmic influences. | Lunar planting calendars, biodynamic compost preparations, and closed-loop nutrient systems. | Traditional |
| Biofloc Aquaculture Integrated with Farming/FlocPonics | West Bengal, Andhra Pradesh, Kerala, and Odisha | Combines fish farming and agriculture with nutrient recycling for water efficiency. | Combining aquaculture with agroforestry or traditional farming. | Growing fish in biofloc systems and recycling wastewater for crop irrigation. | Modern |
| Boro Cultivation | Assam | Winter rice cultivation in low-lying wetlands using traditional water management systems. | Winter-season rice cultivation in wetlands of Assam | Growing short-duration rice varieties in waterlogged fields with minimal inputs. | Traditional |
| Cheruvu Farming | Andhra Pradesh | Community-based farming around water bodies, integrating irrigation and fisheries. | Community-based farming around water tanks (cheruvus) | Tank irrigation combined with rice, fish rearing, and vegetable cultivation. | Traditional |
| Climate-Smart Agriculture | Pan-india | Adaptation and mitigation farming practices to counter climate change. | Resilience to climate change, reducing emissions, and sustainable productivity. | Stress-tolerant crop varieties, agroforestry, and efficient irrigation systems. | Modern |

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|---|---|---|---|---|---|
| Conservation Agriculture | Pan-India | Promotes soil health with minimum tillage, crop rotations, and soil cover. | Soil health, biodiversity, and water conservation. | No-till farming, crop residue retention, and diversified crop rotations. | Traditional |
| Dhan-Yatra Systems | Odisha and parts of Eastern India | Traditional rice irrigation systems focusing on water management. | Water management and cultural connection to farming | Ancient systems of water distribution for rice cultivation in Odisha. | Traditional |
| Dongar Farming | Odisha | Shifting cultivation practiced by tribal communities in hilly areas. | Hill-based rain-fed agriculture practiced in Odisha. | Growing millets and legumes on hill slopes, employing contour bunding for water retention. | Traditional |
| Ecological Farming | Pan-India | Environmentally friendly farming that respects biodiversity and ecosystems. | Harmony with ecosystems and biodiversity conservation. | Polyculture systems, use of natural pest predators, intercropping, and natural fertilizers. | Modern |
| Gautam Krishi/Dhammic agriculture | Bihar | Traditional practices associated with ancient Buddhist teachings | | a Buddhist approach to farming that aims to relieve suffering for people and nature while also promoting economic and environmental justice. | Modern |
| Gavran Sheti | Maharshtra | Maharashtra's indigenous farming using traditional seeds and practices. | Maharashtra's traditional farming emphasizing biodiversity and resilience. | Use of heirloom seeds and minimal mechanization. | Traditional |
| Gomal Krishi | Karnataka | Traditional agro-pastoral systems where cattle grazing lands (gomals) are integrated with farming. | Grazing-based agro-pastoral system | Cattle grazing in communal lands (gomals) combined with cultivation of fodder crops. | Traditional |
| Haritha Krishi | Kerala | | Green, environmentally friendly farming practices | Promoted in Kerala, focusing on eco-friendly | Modern |

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| | | | | inputs and reduced pesticide use. | |
| Hittalagida Cultivation | Karnataka | Home garden-style farming where vegetables, medicinal plants, and spices are grown in small areas, often near the house. | | | Traditional |
| Homa Farming | Maharashtra | A Vedic-based farming practice that uses Agnihotra fire rituals to purify the atmosphere and improve soil health. | Use of Agnihotra rituals for soil and atmosphere purification. | Fire rituals, ash application as fertilizer, and harmonizing energy flow. | Ancient |
| Hugal Farming | Himachal Pradesh, Uttarakhand, and parts of Southern India. | Raised-bed farming using buried organic matter to improve soil health. | Raised beds with buried organic material to enrich soil fertility. | Using decaying wood, twigs, leaves, and compost in layered beds for long-term soil nutrient release. | Modern |
| Integrated Farming Systems | Pan-India | Combines crops, livestock, and aquaculture for resource optimization. | Synergy between crops, livestock, and aquaculture | Crop-livestock integration, nutrient recycling, and multi-layer cropping. | Modern |
| Jaivik Krishi | Pan-India (Hindi-speaking regions) | Refers to organic farming using natural inputs like compost and bio-fertilizers. | Organic farming focused on local biodiversity. | Composting, use of green manure, and vermiculture | Modern |
| Jhum Cultivation | North-Eastern States | Shifting cultivation where patches of forests are cleared and farmed temporarily. | Shifting cultivation for soil rejuvenation. | Clearing and burning forest patches, rotating fields | Traditional |
| Kashyapi Krishi | Bihar and Uttar Pradesh. | Ancient Indian farming inspired by Vedic texts and traditional methods. | Draws inspiration from Kashyapa's ancient agricultural texts. | Incorporates Vedic rituals, water harvesting, and companion planting based on ancient Indian knowledge. | Ancient |

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| Khadin System | Rajasthan | Traditional water harvesting system for farming in arid regions, using earthen bunds to capture runoff for crop irrigation. | Water harvesting for arid regions. | Earthen bunds to capture runoff for farming. | Traditional |
| Kulagar | Goa and Konkan regions | A traditional agroforestry system where crops like betel nut, coconut, and spices are intercropped with food crops. | Agroforestry in the Konkan and Goa regions. | Mixed cropping of coconut, betel nut, and spices. | Traditional |
| Kumari System | Kerala | A form of slash-and-burn cultivation (also called shifting cultivation), used in hilly terrains. | Shifting cultivation in Kerala's highlands | Clearing forest patches, growing crops for one or two cycles, and allowing land to regenerate. | Traditional |
| Malnad Home Gardens | Karnataka (Western Ghats region). | A form of agroforestry in Karnataka's Western Ghats - Multi-tiered gardens combining fruit trees, spices, and vegetables | | Growing spices, medicinal plants, and fruit trees integrated with crops. | Traditional |
| Matka Khad Krishi | Rajasthan, Gujarat, and Maharashtra. | Uses porous earthen pots to create natural fertilizers and boost soil fertility. | Fertilization using Matka Khad (an organic mixture stored in earthen pots). | Use of fermented cow dung, cow urine, jaggery, and water in porous earthen pots to enrich soil. | Modern |
| Mautam Farming | Mizoram | Shifting cultivation that adapts to bamboo flowering cycles, a natural phenomenon occurring every 48 years. | Adaptation to natural bamboo flowering cycles. | Shifting cultivation to mitigate rodent outbreaks caused by bamboo seed consumption. | Traditional |
| Natural Farming | Pan-India | Chemical-free farming emphasizing soil health and natural inputs. | Minimal human intervention and reliance on nature's cycles. | No tilling, no chemicals, mulching, and seed balls. | Modern |

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| Navdanya Farming | Karnataka and Andhra Pradesh | Cultivation of 9 cereals and pulses crops together in a plot. | Focuses on seed sovereignty, biodiversity, and organic farming. | Use of indigenous seeds, crop diversity, and eco-feminist principles in agriculture. | Modern |
| Nimadi Krishi | Nimad region of Madhya Pradesh | Traditional farming in the Nimar region, emphasizing mixed cropping, especially of wheat, cotton, and pulses. | Sustainable farming in the Nimar region of Madhya Pradesh. | Mixed cropping systems of wheat, pulses, and oilseeds, combined with river-based irrigation. | Traditional |
| Organic Farming | Pan-India | Farming without synthetic chemicals, focusing on soil and ecosystem health. | Avoids synthetic inputs and relies on natural processes. | Composting, crop rotations, biological pest control, and certification standards. | Modern |
| Pahadi Krishi | Himachal Pradesh, Uttarakhand, and Arunachal Pradesh. | Mountain farming using terraces and high-altitude crops. | Hill farming using terraces in Uttarakhand and Himachal Pradesh. | Seasonal cropping, livestock integration, and forest-based fertilization. | Traditional |
| Panchgavya Krishi | Maharashtra, and Uttar Pradesh. | Farming with a mixture of five cow-derived products for soil and crop improvement. | Cow-centric organic farming using "Panchgavya" (five cow-derived products: milk, curd, ghee, dung, and urine). | Preparation of nutrient solutions from Panchgavya and applying it for pest control and soil enrichment. | |
| Pannai | Tamil Nadu | Traditional farm management system involving mixed cropping and livestock integration. | Tamil Nadu’s traditional mixed farming system. | Crop-livestock integration and small-scale vegetable farming. | |
| Paschima Vahini Krishi | Maharashtra and Karnataka | Utilizing natural river systems for irrigation, especially in peninsular India. | Traditional west-flowing river-based irrigation | | Traditional |
| Permaculture | Kerala, Tamil Nadu, and Northeastern states | A design philosophy mimicking natural ecosystems for sustainable farming. | Mimics natural ecosystems in farm design | Swale creation, food forests, stacking functions (e.g., multiple uses for one resource), | Modern |

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| | | | | and zone-based planning. | |
| Prakritik Krishi | Pan-India | Translates to "natural farming," emphasizing chemical-free, low-input agriculture. | Nature-based farming avoiding all chemicals. | Mulching, cow dung fertilizers, and companion planting. | Modern |
| Promoting Regenerative And No-burn Agriculture (PRANA) | Punjab, Haryana. | Aims to reduce stubble burning while regenerating soil health. | | | Modern |
| Pukht | Punjab | Traditional method of composting farmyard manure, used extensively in organic farming. | Traditional composting for soil fertility | Farmyard manure composting in pits and its application to fields for soil enrichment. | Traditional |
| Pumlen Pat System | Manipur | A unique wetland-based farming system combining floating gardens for vegetable cultivation and fish rearing. | Wetland-based farming system in Manipur | Floating gardens for vegetables and fish rearing in water bodies. | Traditional |
| Regenerative Agriculture: | Pan-India | Restores soil health, biodiversity, and carbon sequestration. | Restores degraded soil, enhances biodiversity, and sequesters carbon. | No-till farming, cover cropping, agroforestry, composting, and rotational grazing | Modern |
| Rishi Krishi | Maharashtra | A spiritual and natural farming practice inspired by the wisdom of ancient sages. | Spiritual connection to farming with natural methods. | Soil healing with bio-pesticides, natural fertilizers, and energy-based planting. | Modern |
| Sali Paddy Farming | Assam | Traditional monsoon-season rice farming, highly prevalent in Assam’s Brahmaputra Valley. | | | Traditional |

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| Sattvic Farming | Maharashtra, Gujarat, and Tamil Nadu | Farming aligned with Ayurvedic principles and sattvic (pure) crops. | Farming aligned with Ayurvedic and Yogic traditions. | Growing crops considered "sattvic" (pure) and avoiding harmful chemicals and hybrid seeds. | Modern |
| Shivansh farming | Maharashtra | Farming with a focus on rapid composting using local materials for organic farming. | Low-cost organic compost farming. | Fast composting using green and dry biomass. | Modern |
| Siddi Farming | Madhya Pradesh | A system where seeds saved by families over generations (Siddis) are sown, ensuring biodiversity and seed sovereignty. | Tribal farming system emphasizing seed preservation and local biodiversity. | Saving indigenous seeds, rotating crops, and practicing intercropping. | Traditional |
| Simar Cultivation | Jharkhand | Forest-based farming system practiced by tribal communities, integrating crops with natural ecosystems. | Forest-based farming practiced by tribal communities in Jharkhand. | Growing crops under forest canopy, integrating crops like millets, pulses, and medicinal plants with natural ecosystems. | Traditional |
| Subhash Palekar Natural Farming | Himachal Pradesh | Natural farming as advocated by Subash Palekar | A framework for Zero Budget Natural Farming (ZBNF) but further emphasizing indigenous seeds and companion planting. | Jeevamrut, Beejamrut, Waaphasa (soil moisture conservation), and mulching using natural materials. | Modern |
| Sustainable Agriculture: | Pan India | Long-term farming focusing on productivity, ecology, and community welfare. | Focuses on long-term ecological health, soil conservation, water management, and community welfare. | Crop rotation, integrated pest management (IPM), reduced chemical inputs, water conservation techniques, and soil health enhancement. | Modern |
| Tilla Cultivation | Tripura | Farming on elevated lands (tillas) with crops like ginger, turmeric, and vegetables. | Farming on hillocks or elevated land. | Growing crops like ginger, turmeric, and vegetables on elevated slopes using rain-fed irrigation. | Traditional |

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| Vedic Krishi | Pan-India | Refers to farming methods mentioned in ancient Vedic texts, emphasizing natural and spiritual farming practices, including soil and water conservation. | Ancient Indian farming techniques focusing on harmony with nature. | Use of cow dung and urine, moon-phase planting, and mantra-based farming. | Ancient |
| Vriksha Krishi | Maharashtra, Uttar Pradesh, and parts of Karnataka | Tree-based farming rooted in Indian traditions and agroecology | Tree-based farming systems. | Growing food crops and medicinal plants alongside native tree species for sustainable agroforestry. | Traditional |
| Vrikshayurveda | Ancient India | An ancient Indian science of plant life, focusing on sustainable and natural plant care. | Ancient Indian plant care science. | Natural pesticides and care systems derived from traditional texts. | Ancient |
| Zabo Farming | Nagaland | A water conservation-based farming system where water is harvested on hilltops and used for irrigation in terrace fields and practices along with livestock rearing. | Water harvesting with sustainable terraced farming. | Use of hilltop water harvesting and terraced fields | Traditional |
| Zero Budget Natural Farming | Andhra Pradesh, Karnataka | | Zero external costs and use of local resources. | Jeevamrut (bio-fertilizer), Beejamrut (seed treatment), and intercropping. Creating conditions for micro-pores. | Modern |

## Annexure 2: References

*Green manuring*

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