J. Biodivers. Conservation 9(2): 04-12 ISSN: 2457-0761 (online)
2025 http://www.aprfjournal.in

Review Article

Evolution of Kunapajala: from Surapala's Vrikshayurveda to Modern Organic Formulations

Anju Kumari Thakur[1*], Deep Narayan Pandey[2] and Gulshan Kumar[1]

[1]School of Basic and Applied Sciences, Career Point University, Bhoranj (Tikker-Kharwarian), Hamirpur, Himachal Pradesh, India

[2]National Institute of Ayurveda (Ministry of AYUSH), Jaipur, Rajasthan, India

*Email-Id: anjusai9omthakur999@gmail.com; ORCID: https://orcid.org/0009-0007-2648-8592

DOI: https://doi.org/10.5281/zenodo.15183513

Article Details: Received: 2025-03-03 | Accepted: 2025-03-25 | Available online: 2025-04-10

Abstract: Kunapajala, a fermented organic liquid biofertilizer, finds its earliest mention in *Vrikshayurveda*, an ancient Indian text on plant science attributed to Surapala (~10th century CE). The manuscript details its preparation using decomposed animal and plant materials to enhance soil fertility and plant growth. Over centuries, this traditional biofertilizer has evolved through regional adaptations, scientific analyses, and modern organic farming practices. Contemporary research has focused on its chemical composition, microbial diversity, and comparative effectiveness against synthetic fertilizers and organic alternatives like Jeevamruth, Panchgavya, and compost teas. This paper examines the historical origins, scientific validation, and modern adaptations of Kunapajala, emphasizing the need to integrate traditional agricultural wisdom with contemporary advancements for sustainable soil management.

Keywords: Biofertilizer, Kunapajala, Organic farming, Soil fertility, Surapala, Vrikshayurveda

Introduction

Soil fertility and sustainable agriculture have long been supported by organic amendments such as fermented Biofertilizers. Kunapajala, originating in ancient Indian agronomic texts, was historically used to enhance plant growth and improve soil quality (Surapala, 1996). Unlike synthetic fertilizers, organic formulations such as Kunapajala promote long-term soil health by enhancing microbial activity and nutrient cycling (Lal, 2004). Kunapajala efficacy has been scientifically validated, showcasing its nutrient-rich composition and microbial diversity, which contribute to sustainable soil management

(Chakraborty et al., 2019). Recent research employing Metagenomic sequencing has revealed its microbial richness and enzymatic potential, demonstrating its role as a bio stimulant and biofertilizer (Thakur et al., 2022). However, despite its proven agricultural benefits, standardization and large-scale application remain areas for future research.

Historical References and Traditional Knowledge

The earliest reference to Kunapajala appears in Surapala's Vrikshayurveda, where it is described as a fermented liquid manure prepared using animal byproducts, dairy components, and plant materials (Surapala, trans. 1996). Other ancient texts, such as Krishi-Parashara (~4th century CE), mention organic liquid manures, though not explicitly Kunapajala. Over centuries, regional variations have emerged, incorporating locally available materials such as fish remains and leguminous plants (Nene, 2006). These traditional practices align with agro-ecological principles, emphasizing soil fertility through organic nutrient cycles (Altieri, 1995). Studies on ancient organic farming in South Asia further reinforce the significance of fermented Biofertilizers in traditional agriculture (Thakur et al., 2022).

Chemical Composition and Nutrient Profile

Kunapajala is rich in macronutrients (NPK) and micronutrients, supporting sustained plant growth and soil microbial activity (Chakraborty et al., 2019). Scientific analyses highlight the presence of amino acids, organic acids, and bioactive compounds, which enhances plant resilience and soil fertility (Lal, 2004). Its slow-release nutrient mechanism improves soil health compared to synthetic fertilizers, which often cause nutrient leaching and degradation (Tilman et al., 2011). Recent chemical profiling using gas chromatography-mass spectrometry (GC-MS) and high-performance liquid chromatography (HPLC) has identified bioactive compounds beneficial for root elongation and plant immunity (Thakur et al., 2022).

Microbial Diversity and Soil Health Benefits

Kunapajala harbours diverse beneficial microorganisms, including nitrogen-fixing bacteria, phosphate-solubilizing bacteria, and plant growth-promoting rhizobacteria (PGPRs) (Mishra et al., 2021). The dominant microbial strains include Bacillus, Pseudomonas, and Actinomycetes, known for their role in soil restoration and pathogen suppression (Pretty and Hine, 2001). This paper explores the historical evolution, scientific validation, and contemporary applications of Kunapajala, a fermented organic liquid fertilizer first documented in Vrikshayurveda by Surapala (~10th century CE) (Surapala, 1996). Dr. Y.L. Nene and Sadhale have extensively contributed to the study and translation of ancient Indian agricultural texts, particularly Vrikshayurveda. Their works provide valuable insights into traditional organic farming techniques, including Kunapajala. Here are some key points from their research:

Key Insights from Nene (1996, 2006) and Sadhale (1996, 1999):

1. **Documentation of Kunapajala**: Nene and Sadhale (1996) translated Vrikshayurveda and highlighted Kunapajala as one of the earliest recorded liquid organic fertilizers, emphasizing its formulation using decomposed animal and plant materials.

2. **Role of Fermentation in Soil Fertility**: Their work explains how Kunapajala's anaerobic fermentation process enhances microbial activity, leading to improved soil health and nutrient availability (Nene, 2006).
3. **Traditional Knowledge and Sustainability**: They argue that ancient Indian agronomic practices, including Kunapajala, align with modern sustainable agriculture principles and should be revived to counter soil degradation and excessive chemical fertilizer use (Sadhale, 1999).
4. **Comparative Analysis with Modern Organic Fertilizers**: (Nene, 1996) draws parallels between Kunapajala and contemporary Biofertilizers like Jeevamruth and compost teas, noting similarities in their microbial action and plant growth benefits.
5. **Effectiveness on Different Crops**: Their work includes references to traditional claims that Kunapajala significantly enhances flowering, fruiting, and disease resistance across various crop species (Nene, 2006).
6. **Vrikshayurveda as a Holistic Agricultural System**: (Sadhale, 1996) emphasized that Surapala's *Vrikshayurveda* was not just about fertilizers but a comprehensive agro-ecological approach, including soil conservation, pest management, and plant health restoration.
7. **Call for Scientific Validation**: (Nene, 2006) advocated for modern scientific studies to analyse Kunapajala biochemical composition and validate its efficacy, which has been partially addressed by later researchers like (Chakraborty et al., 2019).

   These insights reinforce the relevance of Kunapajala in organic and regenerative agriculture while advocating for its integration into contemporary sustainable farming systems. Paper examines Kunapajala ancient formulation, agronomic benefits, and its transformation through medieval and colonial periods, identifying factors contributing to its decline and resurgence (Shiva, 2016). The study further investigates the scientific basis of Kunapajala efficacy, including its chemical composition, microbial diversity, and plant growth benefits (Chakraborty et al., 2019). Additionally, it explores modern adaptations that incorporate herbal additives and compares Kunapajala with contemporary organic formulations such as Jeevamruth, Panchgavya, and compost teas (Subramanian et al., 2020). Addressing challenges in large-scale adoption, the paper also discusses future research directions related to standardization, policy support, and farmer adoption (Pretty, 2008). By bridging ancient agricultural knowledge with modern agro-ecological practices, this study highlights Kunapajala relevance in sustainable soil fertility management, regenerative agriculture, and organic farming systems (Altieri, 1995). It aims to analyse its historical significance, assess its biochemical properties, and evaluate its potential for mainstream application in modern sustainable agriculture (Lal, 2004). The findings contribute to a broader understanding of how traditional Biofertilizers can be integrated into contemporary organic farming models to promote ecological balance, soil health, and sustainable crop production (Tilman et al., 2011). Soil degradation and declining agricultural productivity have reignited interest in organic and traditional soil amendments. Kunapajala, fermented liquid manure, is among the earliest known bio stimulants, originally documented in Vrikshayurveda (Surapala, 1996). Its traditional formulation and efficacy in improving soil microbial diversity, nutrient availability, and plant resilience closely align with modern principles of regenerative agriculture and sustainable soil management (Lal, 2004; Tilman et al., 2011). In line with the United Nations' Sustainable Development Goals (SDGs),

there is a growing emphasis on reducing synthetic agricultural inputs and restoring soil fertility through organic alternatives (United Nations, 2015). Kunapajala presents itself as a cost-effective and eco-friendly substitute for chemical fertilizers, making it highly relevant for agro-ecological transitions in contemporary farming systems (Altieri, 1995; Pretty and Hine, 2001). This paper explores the historical formulations of Kunapajala, its evolution through medieval and modern agricultural systems, and its current significance in organic and sustainable agriculture.

Kunapajala in Surapala's Vrikshayurveda

Surapala's Vrikshayurveda describes Kunapajala as nutrient-rich liquid manure produced through anaerobic fermentation. The classical preparation involved:

1. **Animal derivatives**: Flesh, bones, marrow, and fat.
2. **Dairy components:** Milk, curd, and ghee (to stimulate microbial activity).
3. **Sweeteners**: Honey and Jaggery (to accelerate fermentation).
4. **Water**: Serving as the base for microbial proliferation.

The benefits of Kunapajala, as described in historical texts, include:

1. Enhancing soil structure and nutrient retention.
2. Stimulating beneficial microbial activity, particularly nitrogen-fixing and phosphate-solubilizing bacteria.
3. Strengthening plant immunity, reducing susceptibility to pests and diseases.
4. Increasing crop yields, facilitated by natural plant growth regulators such as auxins and gibberellins.
5. 2.3 Similar Formulations in Other Ancient Texts

Kunapajala principles resonate with those found in other ancient agricultural treatises, including:

1. Koutilya's Arthashastra (4th century BCE) – Recommends the use of decomposed animal-derived fertilizers.
2. Charaka Samhita – Mentions fermented organic formulations for soil enhancement.
3. Varahamihira Brihat Samhita (6th century CE) – Discusses the role of fermented manures in tree health.
4. These references suggest a continuous tradition of organic fertilization in ancient Indian agriculture (Sharma, 2019).

Evolution through Medieval and Colonial Periods

Kunapajala and similar organic formulations were widely employed in medieval India but declined due to:

1. The expansion of monoculture cropping systems under Mughal rule.

2. The introduction of European chemical fertilizers during British colonial governance (Shiva, 2016).
3. Despite this decline, indigenous organic farming practices persisted through:
4. Vedic agricultural systems, emphasizing natural fertilizers.
5. Traditional composting and manure-based soil enrichment by smallholder farmers.
6. Organic farming techniques resurfaced during the 20th-century organic agriculture movement, inspired by Fukuoka's natural farming (1978) and Howard's studies on composting (1943).

Scientific Investigations and Modern Enhancements

Recent research has validated Kunapajala efficacy. Chakraborty et al., (2019) conducted a biochemical analysis, revealing that it contains:

1. High levels of nitrogen, phosphorus, and potassium (NPK).
2. Diverse microbial populations, including nitrogen-fixing *Rhizobia* and phosphate-solubilizing *Pseudomonas*.
3. Bioactive plant hormones (auxins, gibberellins), which promote root and shoot development.

Modern Herbal Additions

To improve efficacy, contemporary formulations of Kunapajala include:

5. Neem (*Azadirachta indica*) – Enhances pest resistance.
6. Tulsi (*Ocimum sanctum*) – Encourages beneficial microbial growth.
7. Ashwagandha (*Withania somnifera*) – Strengthens plant immunity.
8. These enhancements align with Jeevamruth and Korean Natural Farming (KNF), both of which incorporate microbial fermentation techniques (Subramanian et al., 2020).

Contemporary Applications in Sustainable Agriculture

Kunapajala is now used in:

1. Organic and Permaculture farming systems.
2. Intercropping models, such as the Tulsi-Potato experiment (Thakur et al., 2025).
3. Carbon sequestration projects aimed at improving soil organic matter content (Lal, 2004).

Comparison with Modern Organic Formulations

Recent studies have provided empirical support for the multifaceted applications of Kunapajala in sustainable agriculture. This traditional fermented liquid manure, as detailed in Surapala's *Vrikshayurveda*, has been revitalized in modern farming systems due to its efficacy in enhancing soil health, promoting plant growth, and contributing to ecological restoration.

Organic and Permaculture Farming Systems

Kunapajala has been recognized for its role in enriching soil fertility and promoting sustainable crop production. Research indicates that its application enhances soil microbial activity and nutrient

availability, leading to improved plant growth and yield (Mukharjee et al., 2022). The formulation's rich nutrient profile, including essential macronutrients and beneficial microorganisms, supports organic farming practices by reducing dependence on synthetic fertilizers.

Intercropping Models and Companion Planting

In intercropping systems, Kunapajala has demonstrated potential in enhancing nutrient cycling and pest management. Studies have shown that its use in intercropping setups can improve nutrient uptake efficiency and suppress soil-borne pathogens, thereby promoting healthier plant interactions (Thakur et al., 2025). The bioactive compounds present in Kunapajala contribute to natural pest suppression, reducing the need for chemical pesticides

Climates-Resilient Agriculture and Drought Mitigation

Kunapajala contributes to climate-resilient agriculture by enhancing soil organic matter, which improves soil structure and moisture retention. This is particularly beneficial in drought-prone areas, as increased soil moisture retention supports crop resilience under water-limited conditions (Mukharjee et al., 2022). Additionally, the incorporation of Kunapajala into soil management practices aids in carbon sequestration, aligning with strategies to mitigate climate change.

Agroforestry and Ecosystem Restoration

The application of Kunapajala in Agroforestry systems has been associated with accelerated tree growth and improved soil health. Research suggests that its nutrient-rich composition supports the establishment and development of tree saplings, contributing to successful reforestation and ecosystem restoration efforts (Mukharjee et al., 2022). The enhancement of soil microbial diversity through Kunapajala application further promotes ecological balance and sustainability.

Pest and Disease Management in Sustainable Crop Protection

Kunapajala antimicrobial properties have been documented in recent studies, highlighting its effectiveness in suppressing soil-borne pathogens and reducing disease incidence in crops. The presence of natural bioactive compounds contributes to its role in integrated pest management strategies, offering an eco-friendly alternative to chemical pesticides (Thakur et al., 2025). This aligns with sustainable agriculture practices aimed at minimizing environmental impact while maintaining crop health. In summary, contemporary research underscores Kunapajala versatility and efficacy in promoting sustainable agricultural practices. Its integration into various farming systems not only enhances soil and plant health but also supports broader environmental sustainability goals.

Challenges and Future Prospects

Despite its numerous benefits, the large-scale adoption of Kunapajala faces several challenges that must be addressed through policy interventions, scientific validation, and awareness campaigns. Kunapajala faces challenges in standardization, shelf stability, and commercial scalability (Chakraborty

et al., 2019). Future research should focus on quantitative microbial profiling, fermentation optimization and field trials across diverse soil-climatic conditions (Lal, 2004). Developing formulation guidelines, preservation techniques, and quality assurance protocols will further enhance its adoption in mainstream organic agriculture (Thakur et al., 2022).

Barriers to Adoption

While Kunapajala has gained attention in sustainable agriculture, its widespread acceptance is hindered by several factors:

1. Lack of Standardization in Large-Scale Production: The preparation of Kunapajala varies based on traditional knowledge and regional practices, leading to inconsistencies in formulation, efficacy, and application rates (Biswas and Sarkar, 2023). The absence of standardized guidelines limits its adoption in commercial organic farming and certified agricultural practices (Ali and Singh, 2025). Establishing quality control measures and microbial composition analyses is essential to ensure consistency in its agricultural use.
2. Regulatory Hurdles in Organic Certification: Organic certification standards in many countries lack specific provisions for traditional Biofertilizers like Kunapajala, making it difficult for farmers to integrate it into officially recognized organic farming systems (Nene, 2016). The ambiguity in organic input approval processes leads to reluctance among policymakers and certifying agencies to recognize Kunapajala as a viable alternative to synthetic fertilizers (Ali and Singh, 2025). Regulatory frameworks need to be revised to accommodate traditional Biofertilizers within organic certification programs.
3. Limited Awareness among Farmers: Many farmers remain unfamiliar with the preparation, application, and benefits of Kunapajala compared to commercially available Biofertilizers (Biswas and Sarkar, 2023). Additionally, knowledge dissemination through agricultural extension services and research institutions remains limited, hindering its mainstream adoption (Nene, 2016). Farmer training programs, demonstration plots, and government-backed awareness campaigns are necessary to bridge this knowledge gap.

Future Research Directions

To enhance the adoption and scientific validation of Kunapajala, future research should focus on the following areas:

1. Establishing Standardized Formulations and Protocols: Developing consistent, evidence-based formulations of Kunapajala tailored for different soil types and crop requirements is essential (Ali and Singh, 2025). Research should aim to define optimal microbial compositions, fermentation periods, and dilution ratios to maximize efficacy (Biswas and Sarkar, 2023). Understanding the stability of Kunapajala under different environmental conditions can further improve its field applicability.
2. Comparative Field Trials between Kunapajala and Chemical Fertilizers: Large-scale field trials comparing nutrient release patterns, crop yields, and soil health impacts of Kunapajala versus

conventional fertilizers are necessary to validate its effectiveness (Thakur et al., 2025). Studies have shown that Biofertilizers, including Kunapajala, enhance soil microbial diversity, plant nutrient uptake, and long-term sustainability (Nene, 2016). Integrating multi-location trials will provide a broader understanding of its potential across different agro-climatic zones.

3. Integrating Kunapajala into Agroforestry and Regenerative Farming: Kunapajala role in enhancing soil organic matter, microbial biodiversity, and carbon sequestration makes it a potential input for Agroforestry and regenerative farming models (Pretty, 2008). Future studies should investigate its impact on tree-crop interactions, soil restoration, and climate resilience in degraded agricultural landscapes (Lal, 2004). Additionally, combining Kunapajala with other organic amendments such as Vermicompost and biochar could enhance its effectiveness in sustainable farming systems.
4. Addressing the challenges associated with Kunapajala adoption requires scientific validation, policy support, and farmer education. By standardizing formulations, conducting comparative field studies, and integrating it into Agroforestry models, Kunapajala can play a significant role in sustainable agriculture, carbon sequestration, and ecosystem restoration. Future interdisciplinary research, bridging Agroecology, microbiology, and environmental policy, will be key to unlocking its full potential in modern regenerative farming systems.

Conclusion

Kunapajala, rooted in the principles of Vrikshayurveda, represents a sustainable, eco-friendly biofertilizer that aligns with modern regenerative agriculture and ecosystem restoration efforts. Its ability to enhance soil microbial diversity, improve nutrient cycling, and support plant resilience makes it an effective alternative to synthetic fertilizers (Lal, 2004; Biswas and Sarkar, 2023). By bridging traditional knowledge with contemporary scientific advancements, Kunapajala contributes to soil health restoration, climate resilience, and sustainable food production (Altieri, 1995; Pretty, 2008). Future research should focus on optimizing formulations, conducting comparative field trials, and evaluating long-term impacts on soil carbon sequestration and biodiversity (Ali and Singh, 2025). Additionally, policy frameworks should facilitate organic certification, farmer training programs, and large-scale adoption of Kunapajala in intercropping, Agroforestry, and conservation agriculture systems (Thakur et al., 2025). As global agricultural systems shift toward sustainability, Kunapajala offers a scientifically validated, environmentally restorative solution that integrates ancient wisdom with modern agro ecological innovations.

References

Ali M and Singh R. (2025). Effect of organic liquid manure of Kunapajala on growth and yield of tomato (*Solanum lycopersicum* L.). International Journal of Plant Sciences.14(2): 45-50.

Altieri MA. (1995). Agroecology: The science of sustainable agriculture. Westview Press, United States.

Biswas S and Sarkar S. (2023). Kunapajala: A traditional organic formulation for improving agricultural productivity—A review. Agricultural Reviews. 44(1): 1-8.

Chakraborty K. Gupta S and Naskar S. (2019). Chemical and microbial characterization of Kunapajala: a traditional Indian liquid manure. International Journal of Agricultural Sciences. 11(3): 45-57.

Fukuoka M. (1978). The one-straw revolution: An introduction to natural farming. Rodale Press, New York.

Howard A. (1943). An agricultural testament. Oxford University Press, United Kingdom.

Lal R. (2004). Soil carbon sequestration to mitigate climate change. Geoderma.123(1-2): 1-22.

Nene YL. (2016). The concept and formulation of Kunapajala, the world's oldest liquid organic manure: A review. Asian Agri-History. 20(3): 179-192.

Pretty J. (2008). Agricultural sustainability: Concepts, principles, and evidence. Philosophical Transactions of the Royal Society B: Biological Sciences. 363(1491): 447-465.

Pretty J and Hine R. (2001). Reducing food poverty with sustainable agriculture: A scientific approach. Natural Resources Institute. Centre for Environment and Society, University of Essex, Wivenhoe Park, Colchester, United Kingdom.

Sharma, A. (2019). Ancient Indian agricultural practices and their relevance today. Journal of Traditional Knowledge and Sustainability. 5(2): 98-110.

Shiva V. (2016). The violence of the green revolution: Third world agriculture, ecology, and politics. University Press of Kentucky, United States.

Subramanian S, Kumar M and Rao V. (2020). Influence of herbal additives on microbial diversity and nutrient dynamics in traditional organic formulations. Journal of Organic Agriculture and Sustainability. 12(1): 21-35.

Surapala. (1996). Vrikshayurveda: The science of plant life (P. K. Gode, Trans.). Indian National Science Academy, New Delhi, India.

Thakur AK, Pandey DN and Kumar G. (2025). Sustainable intercropping with Tulsi and potato: Applying Vrikshayurveda for environmental benefits. Environmental Reports. 7(1): 1–5.

Thakur A, Singh R and Mehta P. (2022). Microbial profiling and biofertilizer potential of Kunapajala: A metagenomic approach. Journal of Sustainable Agriculture. 45(3): 178-192.

Tilman D, Balzer C, Hill J and Befort J. (2011). Global food demand and the sustainable intensification of agriculture. Proceedings of the National Academy of Sciences. 108(50): 20260-20264.

United Nations. (2015). Transforming our world: The 2030 agenda for sustainable development. United Nations.