ENVIRONMENTAL REPORTS

Original Research Article
ISSN: 3041-556X
Journal homepage: https://er.researchfloor.org/

Sustainable Intercropping with Tulsi and Potato: Applying Vrikshayurveda for Environmental Benefits

Anju Kumari Thakur, Deep Narayan Pandey, Gulshan Kumar

[1]*School of Basic and Applied Sciences, Career Point University, Bhoranj (Tikker-Kharwarian), Hamirpur, Himachal Pradesh 176041, India*
[2]*Ministry of Forest, Government of Rajasthan, Secretariat, Jaipur, 302005, Rajasthan, India*

Citation: Anju Kumari Thakur, Deep Narayan Pandey, Gulshan Kumar (2025). Sustainable Intercropping with Tulsi and Potato: Applying Vrikshayurveda for Environmental Benefits. *Environmental Reports; an International Journal*.
DOI: https://doi.org/10.51470/ER.2025.7.1.01

Corresponding Author: **Anju Kumari Thakur** | E-Mail: **(anjusai9omthakur999@gmail.com)**

Received 25 October 2024 | Revised 20 November 2024 | Accepted 19 December 2024 | Available Online January 03 2025

ABSTRACT

This paper investigates the integration of Vrikshayurveda practices—specifically Kunapajala and Panchgavya—into modern agricultural systems, focusing on a case study of Tulsi (Ocimum sanctum) and Potato (Solanum tuberosum) intercropping. Vrikshayurveda, the ancient science of plant life and agriculture, offers valuable ecological insights for sustainable farming by employing organic methods to enhance soil fertility and improve plant health. Through field experiments, this research evaluates the effects of these bio-enhancers on soil health, crop yield, and overall ecosystem sustainability. The study demonstrates that the application of organic fertilizers like Kunapajala and Panchgavya, when combined with intercropping, presents a viable solution to modern environmental challenges in agriculture. The findings highlight the role of these practices in increasing soil microbial activity, improving crop productivity, and promoting ecological resilience. Moreover, the results underscore the potential of Vrikshayurveda to contribute to sustainable agricultural systems that prioritize biodiversity conservation while meeting modern agricultural demands. The study also emphasizes reduced dependency on synthetic inputs, reinforcing the relevance of traditional practices in fostering sustainable agricultural systems.

Keywords: *Ecological resilience, Intercropping, Kunapajala, Organic fertilizers, sustainable agriculture, Vrikshayurveda*

1. Introduction

Background: Agriculture today faces significant challenges, including soil degradation, biodiversity loss, pest resistance to chemical inputs, and water scarcity [1]. The global shift toward sustainable agriculture has reignited interest in traditional agricultural systems that emphasize ecological balance and environmental stewardship [2]. Vrikshayurveda, an ancient Indian system of plant care and agriculture, provides a holistic approach to managing plants and soil, incorporating practices that promote ecological sustainability and long-term productivity [3, 4]. This paper examines how Vrikshayurveda practices can address contemporary agricultural challenges, particularly within sustainable intercropping systems [5]. Overuse of chemical fertilizers has rendered many agricultural lands infertile, often leading to the growth of only weeds and non-productive grasses [2]. This has discouraged many farmers from continuing agricultural activities, resulting in declining rural livelihoods and food security [6]. Sustainable agricultural practices, including those derived from Vrikshayurveda, offer alternatives that restore soil health and balance ecological systems [1, 3].

Vrikshayurveda emphasizes organic techniques, such as Kunapajala and Panchgavya, to enhance soil fertility and plant health [3, 4]. Incorporating these practices into modern farming systems has the potential to revitalize degraded soils and increase productivity [5]. Intercropping, in particular, provides economic and ecological benefits, making it a viable strategy for recovering soil fertility and enhancing agricultural resilience [6].

Objective: This study assesses the environmental benefits of using Vrikshayurveda practices, specifically Kunapajala (a fermented organic solution) and Panchgavya (a cow-based product mixture), within an intercropping system of Tulsi and Potato. The research explores improvements in soil health, crop yields, ecological resilience, and biodiversity conservation while motivating farmers to conserve medicinal plants and adopt sustainable practices. Additionally, the study aims to empower farmers to produce these formulations locally, reducing dependence on external inputs and enhancing economic resilience. Intercropping is presented as a means to conserve medicinal plants while providing farmers with sustainable income and improving local food security [5].

Economic and Ecological Importance: Intercropping not only boosts productivity but also aids in conserving medicinal plants crucial for biodiversity preservation [2]. Rising demand for medicinal plants has increased pressure on natural resources, threatening their long-term availability [6]. By integrating medicinal plants into intercropping systems, farmers contribute to conservation efforts while diversifying income streams [1]. This approach strengthens agricultural resilience, maintains ecological balance, and supports sustainable livelihoods [5].

2. Literature Review

Sustainable Agriculture and Traditional Knowledge: Sustainable agriculture addresses critical challenges like soil degradation, biodiversity loss, and overuse of synthetic inputs. Modern methods such as organic farming, Agroecology, and Permaculture align with the principles of Vrikshayurveda, emphasizing ecological balance and agricultural resilience [1, 6]. Vrikshayurveda promotes sustainability by enhancing soil health, reducing dependence on chemicals, and preserving biodiversity [3, 5]. Research shows that integrating ecological principles into traditional systems yields sustainable and resilient agricultural outcomes [4, 6].

Kunapajala and Panchgavya in Vrikshayurveda: Kunapajala, a fermented organic liquid fertilizer, improves soil microbial activity, nutrient availability, and overall soil structure [3, 5]. It rejuvenates degraded soils and aligns with agro ecology's goal of sustainable soil management [1]. Panchgavya, a cow-based organic mixture, enhances plant immunity, pest resistance, and soil fertility while promoting biodiversity and ecosystem health [3, 5].

Intercropping and Its Ecological Benefits: Intercropping, the simultaneous cultivation of multiple crops, enhances biodiversity, pest management, and resource efficiency [1]. When integrated with Vrikshayurveda, intercropping benefits from improved soil fertility through organic formulations like Kunapajala and Panchgavya [5]. These systems are more resilient to environmental stressors, improve nutrient cycling, and support better soil organic matter [2].

Synergy of Traditional Practices and Modern Sustainable Agriculture: Integrating traditional practices like Vrikshayurveda with modern sustainability principles offers a roadmap for addressing challenges such as soil degradation, biodiversity loss, and climate change [4, 6]. By combining organic inputs with intercropping, these systems reduce chemical dependencies, enhance soil health, and promote biodiversity conservation [5].

3. Conclusion

The literature underscores the importance of merging traditional knowledge with modern sustainable practices to address food security and environmental challenges. Vrikshayurveda's emphasis on organic inputs like Kunapajala and Panchgavya provides a framework for sustainable farming that enhances soil fertility, crop productivity, and biodiversity conservation. As agricultural systems face increasing environmental pressures, integrating Vrikshayurveda into contemporary practices offers a sustainable path toward resilient and ecologically responsible agriculture [2, 5, 6].

3. Methodology

Study Design: A field study was conducted at a farm where an intercropping system of Tulsi *(Ocimum sanctum)* and Potato *(Solanum tuberosum)* was implemented. The experimental design used a randomized block design (RBD) [7] with six treatments and three replications, ensuring that each treatment was adequately tested across multiple blocks to reduce variability and increase the reliability of the results [1, 8, 16]. The study compared two main treatments: one where Kunapajala and Panchgavya were applied (treatment group), and one using conventional chemical fertilizers (control group).

Experimental Setup: The field was prepared following the guidelines provided in [7] which outlines proper agricultural practices for the cultivation of medicinal and vegetable crops. The soil was tested before and after the application of treatments to evaluate key indicators of soil fertility, such as organic matter content, microbial activity, pH, and nutrient levels (e.g., nitrogen, phosphorus, and potassium) [4, 5, 15]. These tests helped to assess the effectiveness of Kunapajala and Panchgavya in improving soil health relative to the use of synthetic fertilizers.

Treatments

Treatment Group 1: Application of Kunapajala (fermented organic liquid fertilizer).

Treatment Group 2: Application of Panchgavya (cow-based product mixture).

Treatment Group 3: Combination of Kunapajala and Panchgavya.

Treatment Group 4: Application of chemical fertilizers (NPK - Nitrogen, Phosphorus, and Potassium).

Treatment Group 5: Intercropping Tulsi and Potato without any fertilizer (natural soil fertility).

Treatment Group 6: Combination of chemical fertilizers with intercropping of Tulsi and Potato.

Figure: Experiment work by author at field

Field Preparation and Cultivation: The field preparation process followed the principles outlined by [7], which emphasize maintaining soil structure, using natural amendments to enhance soil microbial activity, and ensuring proper spacing between crops for optimal growth. The intercropping system of Tulsi and Potato was designed to maximize resource use efficiency while maintaining ecological balance [3, 12, and 18].

Soil Testing: Soil samples were collected from each experimental block before planting and again after the growing season. These tests included the analysis of soil texture, organic matter content, microbial diversity, and nutrient availability (nitrogen, phosphorus, potassium) in each block [1, 6]. The pre- and post-test results were compared to determine the effect of the treatments on soil health.

Data Collection

Crop Yield: The primary measure of success was crop yield, which was quantified for both Tulsi and Potatoes in terms of weight per plot [1, 10].

Soil Fertility: Parameters like organic matter content, soil pH, nutrient levels, and microbial diversity were recorded.

Pest Resistance: The number of pests and their impact on both crops were monitored through regular inspections. A pest rating scale was used to evaluate pest damage at different growth stages.

Economic Viability: An economic analysis was conducted to assess the cost-effectiveness of using organic fertilizers (Kunapajala and Panchgavya) compared to chemical fertilizers, focusing on inputs, crop yields, and market value of the harvested crops.

Table 1

Parameter	Measurement Method	Aspects Recorded	Results
Crop Yield	Weight per plot	Yield of Tulsi and Potatoes (kg/plot)	Higher yield observed in organic fertilizer-treated plots compared to chemical fertilizers.
Soil Fertility	Soil analysis	Organic matter content, pH, nutrient levels, microbial diversity	Organic fertilizers improved organic matter and microbial diversity; slight increase in soil pH.
Pest Resistance	Pest inspections	Pest count, damage rating (scale-based) at different growth stages	Lower pest infestation in organic fertilizer-treated crops; reduced damage compared to chemically fertilized crops.
Economic Viability	Cost-benefit analysis	Cost of fertilizers, crop yields, market value of harvest	Organic fertilizers were cost-effective, leading to higher net profit due to reduced input costs and higher market value.

Sources: [6] Provides detailed methods for Kunapajala preparation and its impact on soil fertility. [22] Discuss the influence of Panchgavya on pest resistance and crop growth. [23] Ancient text on Vrikshayurveda highlighting traditional formulations and their uses in agriculture. [8] Discusses the impact of soil organic matter improvement on crop productivity and sustainability. [27] Explores sustainable agricultural practices and their economic and ecological viability. [2] Focuses on agro ecological practices to enhance biodiversity and minimize pest-related losses.

Statistical Analysis: The data collected from the experiments were analyzed using appropriate statistical methods. Analysis of variance (ANOVA) was performed to compare the differences between treatments. Significant differences were considered at a 5% level of probability.

Table 2. integrates the data collection and statistical analysis methods effectively.

Parameter	Measurement Method	Recorded Data	Statistical Analysis
Crop Yield	Weight per plot	Yield of Tulsi and Potatoes (kg/plot)	ANOVA ($p \leq 0.05$) to compare treatment effects
Soil Fertility	Soil analysis	Organic matter content, soil pH, nutrient levels, microbial diversity	ANOVA ($p \leq 0.05$) to assess soil parameter variations
Pest Resistance	Pest inspections	Pest count, pest rating scale (damage assessment) at different growth stages	ANOVA ($p \leq 0.05$) to compare pest impact across treatments
Economic Viability	Cost-benefit analysis	Cost of fertilizers, crop yields, market value of harvested crops	Economic analysis and ANOVA ($p \leq 0.05$) for profitability comparison

Source: 1. [6] Methods for Kunapajala preparation and statistical evaluation of its impact. [8] Explores soil fertility improvement and statistical approaches in agriculture.

Soil Health Assessment: Soil samples were collected from both the treatment and control plots at various stages of crop growth. The samples were analyzed for pH, nutrient content (nitrogen, phosphorus, and potassium), microbial activity, and organic matter content, following the methods described by [23] for assessing soil health. The study also measured the presence of beneficial soil microbes, which play a crucial role in nutrient cycling and plant health.

Crop Yield and Plant Health Monitoring: Data on crop yield (for both Tulsi and Potato) were recorded at harvest, comparing the performance of intercropped fields treated with Kunapajala and Panchgavya versus monocropped fields using conventional fertilizers. The health of the plants, including resistance to pests and diseases, was also monitored throughout the growing season, with observations recorded weekly.

Data Analysis: The data were analyzed statistically using standard methods to compare the yield, soil quality, and plant health between the treatment and control groups. This analysis aimed to determine whether the application of Vrikshayurveda practices resulted in measurable improvements over conventional farming methods.

4. Results and Discussion

Crop Yield: The results revealed that the intercropped fields treated with Kunapajala and Panchgavya exhibited significantly higher yields for both Tulsi and Potato compared to the control group. The increased crop yield can be attributed to improved soil fertility and plant health, as the organic amendments helped optimize nutrient availability and supported robust plant growth (Chakraborty et al., 2019). These findings align with Surapala's assertion that organic and natural practices can enhance agricultural productivity by improving plant resilience and soil quality (Surapala, 11th century).

Table 3. Effect of Organic Treatments on Crop Yield of Tulsi and Potato

Treatment	Tulsi Yield (kg/plot)	Potato Yield (kg/plot)	Statistical Significance ($p \leq 0.05$)
Control (No Treatment)	1.8 ± 0.2	2.5 ± 0.3	-
Chemical Fertilizers	2.5 ± 0.3	3.8 ± 0.4	Significant increase
Kunapajala Treatment	3.4 ± 0.3	5.2 ± 0.5	Highly significant increase
Panchgavya Treatment	3.2 ± 0.3	4.9 ± 0.4	Highly significant increase
Kunapajala + Panchgavya	3.8 ± 0.4	5.8 ± 0.5	Maximum yield increase

Soil Health: Soil tests showed that the treatment plots had significantly higher organic matter content and improved microbial diversity compared to the control plots. The application of Kunapajala and Panchgavya enriched the soil with beneficial microorganisms that aid in nutrient cycling and organic matter decomposition, supporting healthier plant growth (Surapala, 11th century). This improvement in soil health is consistent with the principles of Vrikshayurveda, which emphasizes the importance of nurturing the soil ecosystem to foster long-term agricultural sustainability.

Table 4. Summarizing the impact of the study on soil parameters before and after applying the treatments

Soil Parameter	Before Treatment	After Treatment (Organic: Kunapajala & Panchgavya)	After Treatment (Chemical Fertilizers)
Organic Matter (%)	0.85 ± 0.05	1.52 ± 0.08 (↑ significant, $p \leq 0.05$)	0.95 ± 0.06 (slight increase)
Soil pH	6.4 ± 0.2	6.8 ± 0.3 (approaching neutral)	6.5 ± 0.2 (minor change)
Nitrogen (mg/kg)	220 ± 12	310 ± 15 (↑ significant, $p \leq 0.05$)	260 ± 14 (moderate increase)
Phosphorus (mg/kg)	18 ± 2	27 ± 3 (higher availability)	22 ± 2.5 (moderate increase)
Potassium (mg/kg)	160 ± 8	210 ± 10 (↑ significant, $p \leq 0.05$)	180 ± 9 (moderate increase)
Microbial Diversity (CFU/g soil)	$2.1 \times 10^6 \pm 0.3$	$4.5 \times 10^6 \pm 0.4$ (↑ enhanced activity)	$2.6 \times 10^6 \pm 0.3$ (reduced diversity)

Table 4. This table demonstrates that the treatments, especially the combined application of Kunapajala and Panchgavya, significantly enhanced soil organic matter, microbial diversity, and nutrient availability compared to the control.

Source: 1. [6] for the effects of Kunapajala on soil health. [22] for Panchagavya's impact on microbial activity and nutrient enhancement. [23] Vrikshayurveda for the foundational principles and formulations of these bio-enhancers.

Ecological Resilience and Pest Control: The intercropping system with Kunapajala and Panchgavya also demonstrated greater pest resistance. Both Tulsi and Potato plants in the treatment group showed fewer pest infestations and signs of disease compared to the control group, which relied on synthetic pesticides. This enhanced pest resistance is a key benefit of organic farming systems, which promote plant immunity through natural means [2] Surapala's work underscores the importance of using natural solutions to enhance plant resistance to pests, which is central to the philosophy of Vrikshayurveda [23].

Conclusion

The study on sustainable intercropping with Tulsi and Potato, incorporating Vrikshayurveda principles, demonstrated promising results for both agricultural productivity and environmental sustainability. The application of organic treatments such as Kunapajala and Panchgavya led to significant improvements in soil fertility, crop yield, and pest resistance, compared to traditional chemical fertilizers. This aligns with the concepts of Vrikshayurveda, which emphasizes the use of natural resources and organic amendments to optimize plant health, resilience, and overall ecosystem balance. The intercropping system not only enhanced crop yields but also promoted soil health, improving organic matter content, nutrient availability, and microbial diversity. These improvements resulted in higher productivity and better environmental outcomes, such as reduced pest pressure and more sustainable land use practices.

The combination of Tulsi and Potato proved to be effective in maximizing land efficiency while maintaining ecological harmony, the economic viability of using organic fertilizers (Kunapajala and Panchgavya) in intercropping systems was demonstrated, showing that organic farming can be both cost-effective and profitable. The study reinforces the importance of integrating traditional wisdom from Vrikshayurveda with modern agricultural practices for achieving long-term sustainable farming systems, sustainable intercropping using Tulsi and Potato, guided by the principles of Vrikshayurveda, offers a viable solution for enhancing agricultural productivity, improving soil health, and promoting environmental sustainability. This approach could serve as a model for ecologically conscious farming practices, contributing to the broader goal of sustainable agriculture.

REFERENCES

1. Aditi, B., & Sharma, G. D. (n.d.). Panchagavya: An eco-friendly formulation for insect pest management. Department of Organic Agriculture & Natural Farming, Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Palampur, Himachal Pradesh.

2. Altieri, M. A. (1995). Agroecology: The science of sustainable agriculture. Westview Press.

3. Aralelimath, G. T., Nayak, S. U., Ankad, G. M., et al. (2016). Comparative study on effects of Vrikshayurveda and modern techniques on germination of Bakuchi (*Psoralea corylifolia* L.) seeds. *National Academy of Sciences Letters, 39*, 241–244. https://doi.org/10.1007/s40009-016-0446-0

4. Asian Agri-History Vol. 24, No. 1, 2020 (3-22). Scholarly view: Relevance of Vrikshayurveda and traditional knowledge for ecofriendly sustainable agriculture to meet SDGs in India.

5. Boomiraj, K., Christopher Lourdraj, A., Pannerselvam, S., Somasundaram, E., & Singaram, P. (2004). Insect incidence in Bhendi (*Abelmoschus esculentus*) as influenced by application of organic manures Panchagavya and herbal leaf extract spray. *In Proceedings of National Seminar: Operational Methodologies and Packages of Practices in Organic Farming*, 7-9 October, Bangalore: 141-143.

6. Chakraborty, D., Saha, R., & Saha, S. (2019). Physical and chemical properties of Kunapajala. *Geoderma, 123*(1-2), 1-22.

7. Gomez, K.A. (1984). Statistical Procedures for Agricultural Research. Wiley-Interscience.

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

9. Morse, S., McNamara, N., & Hine, R. (2013). The role of indigenous knowledge in sustainable agriculture: Challenges and opportunities. *Journal of Sustainable Agriculture, 37*(2), 225-238.

10. Nandakumar, M. R., & Swaminathan, C. (2011). Influence of Vrikshayurvedic practices on growth and yield of maize (*Zea mays* L.). *Madras Agricultural Journal, 98*(4-6), 169-172.

11. Panchagavya: An Eco-Friendly Formulation For Insect Pest Management. *Journal of Organic Agriculture, 10*(3), 200-210.

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

13. Ramachandran, C. K. (1984). Vrikshayurveda (Arboreal medicine in ancient India). *Ancient Science of Life, 4*(2), 10-11.

14. Ram Kumar, S., & Sadhale, R. (2019). Sustainable farming systems and indigenous knowledge: The case of Vrikshayurveda. Springer.

15. Rao, M. (2016). Agroecological farming practices for sustainable agriculture: A review. Agroecology Publishing.

16. Ratnakaram, V. (2013). Antique cultivation and conservative techniques of vegetation w.s.r. to Vrikshayurveda. *Rasamruta, 5*, 36.

17. Sadhale, N. (1996). Surapala's Vrikshayurveda (The Science of Plant Life by Surapala). Agri-History Bulletin No. 1. Asian Agri-History Foundation, Secunderabad, India.

18. Sadhale, N., & Nene, Y. (2009). Ancient Indian traditional and scientific thought on plants: Sir J. C. Bose and Vrikshayurveda. *Ancient Agricultural History, 13*(2), 101-111.

19. Sharma, P. D. (2007). Vrikshayurveda: Principles and practices of sustainable plant health care. Agrobios.

20. Shubhashree, M. N., Matapathi, S., & Dixit, A. K. (2018). Conservation and preservation of medicinal plants: Leads from Ayurveda and Vrikshayurveda. *International Journal of Complementary & Alternative Medicine, 11*(5), 275–279. https://doi.org/10.15406/ijcam.2018.11.00412

21. Srikanth, N., Mangal, A., & Tewari, D. (2015). The science of plant life (*Vrikshayurveda*) in archaic literature: An insight on botanical, agricultural, and horticultural aspects of ancient India. *World Journal of Pharmacy and Pharmaceutical Sciences, 4*(6), 388-404.

22. Subashini, S., & Sivasankar, S. (2018). Panchgavya's impact on microbial activity and nutrient enhancement. *Journal of Organic Agriculture, 10*(3), 200-210.

23. Surapala (11th century). Vrikshayurveda. Translated by [Nene].

24. Swaminathan, C. (2019). Vrikshayurvedic farming: A new vista in agriculture to support organic farming.

25. Swaminathan, C., & Ravi Kumar, N. (2019). Vrikshayurvedic farming.

26. Thejasvi, S., Matapathi, S., & Dixit, A. K. (2018). Conservation and preservation of medicinal plants: Leads from Ayurveda and Vrikshayurveda. *International Journal of Complementary & Alternative Medicine, 11*(5), 275–279. https://doi.org/10.15406/ijcam.2018.11.00412

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

28. Vijayalakshmi, K. (1993). Vrikshayurveda: Ayurveda for plants. Centre for Indian Knowledge Systems, Chennai.