Organic Farming and the Agricultural Wisdom of Ancient India: An Exploration of Sustainable Agroecology

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Summary

This review explores the synergy between modern organic farming and the ancient agricultural practices of India, emphasizing their combined potential to promote sustainable agriculture. Through an in-depth analysis of historical texts, ancient scriptures and archaeological discoveries, the study highlights the principles and methods that have defined India's traditional agricultural systems. Key practices such as Kunapajala, Panchagavya and herbal pest control are examined for their relevance and efficacy in contemporary organic farming. The integration of these ancient techniques offers numerous benefits, including enhanced soil health, biodiversity conservation, reduced environmental impact and increased climate resilience. Despite challenges such as the need for scientific validation and adaptation to changing climates, the amalgamation of traditional wisdom with modern organic practices provides a holistic approach to agriculture. This approach addresses ecological, cultural, economic and social dimensions as well, aiming to create resilient and environmentally responsible farming communities.

Key words

Vrikshayurveda, sustainable agriculture, conventional farming, organic agriculture

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Introduction

Organic agriculture has garnered considerable attention recently as a viable and sustainable ecological alternative to conventional farming methods. With its emphasis on natural processes, biodiversity preservation and reduced chemical use, it offers promising solutions to pressing agricultural issues such as soil degradation, water pollution, and biodiversity loss. However, a significant gap exists in current research regarding the synergistic potential of merging modern organic farming with the wisdom of age-old agricultural knowledge.

India, recognized for its diverse traditional medical systems, also boasts a deep-rooted agricultural legacy based on sustainable techniques and ecological principles. Practices like 'Agnihotra' and 'Panchagavya' have long been foundational to Indian agriculture, drawing from ancient wisdom for soil and livestock management. However, the extent to which these traditional methods align with contemporary organic farming principles and contribute to sustainable agriculture remains inadequately explored in current discussions (Twarog, 2006).

This review aims to bridge this gap by exploring the deep-seated connection between organic farming and the agricultural wisdom of ancient India. By analyzing insights derived from historical texts, ancient scriptures and archaeological findings, we will elucidate the fundamental principles and methodologies that defined traditional agricultural practices. Highlighting both the strengths and limitations of these practices, we will demonstrate their potential to contribute to the progression of sustainable agriculture. In pursuing this objective, we advocate for a holistic, comprehensive approach to agriculture that merges traditional knowledge with modern techniques. Sustainable agriculture, by definition, recognizes the interdependence of ecology, culture, economy and society. By taking into account all participants within the agricultural ecosystem, the objective is to establish resilient and flourishing farming communities capable of withstanding environmental adversities.

Traditional Agricultural Wisdom in Ancient India

India boasts a rich legacy of agricultural knowledge documented in ancient texts. Pioneering works like "Krishi Parashara" (400 BCE) by Parashara and "Vrikshayurveda" (1000 CE) by Surapala offer valuable insights into traditional agricultural practices. "Vrikshayurveda," considered the first comprehensive text on arboriculture in Sanskrit, extensively discusses Kunapajala, a fermented plant protectant and liquid fertilizer made from animal waste – a practice highly relevant to modern organic farming.

Many other texts on agriculture were composed in Sanskrit and various Indian languages between 800-1600 CE in Bharatvarsha. Table 1 (Jidesh, 2018; VijayKumar et al., 2022; Merzlaya, 2022; Sadhale & Shah, 1999) provides further examples of these literary treasures, highlighting the vast knowledge base embedded in these ancient texts. The historical evidence (Newton, 1983; Nene, 2018) underscores the long-standing agricultural heritage of India, dating back to the Rigveda (8000 BCE). Notably, these methodologies have evolved organically, integrating traditional management techniques that contribute to their sustainability.

The enduring presence of these practices in various nations, including contemporary India (as highlighted by Das et al., 2021), underscores the potential of integrating this time-tested wisdom into modern agricultural systems for a more sustainable future.

Interface between Organic Farming Techniques and Traditional Knowledge

Kunapajala has the honor of being acknowledged as the world's inaugural fermented liquid fertilizer and has been extensively recorded in Vrikshayurveda texts from the 9th century through the mid-20th century. These texts strongly advocate for the production of Kunapajala, labelling it as the ancient organic liquid manure (Nene, 2018). Initially, this fertilizer was created from refuse materials, including cooked and fermented animal remains, bone marrow and fat, all amalgamated with cow dung and urine. Additionally, it is important to note that this concoction was enriched with milk, yogurt and clarified butter. Consequently, the resultant liquid was spread on the soil encircling trees and shrubs, resulting in remarkable growth and increased yield, as confirmed by Sadhale in 1996. The historical importance and effectiveness of Kunapajala as a fermented liquid fertilizer emphasize its potential relevance in contemporary agricultural methods. Despite being described centuries ago, the true nature and usefulness of Kunapajala were only unveiled in 2018, as documented by Nene. Furthermore, its vegetarian versions have been recognized since 2004 and 2012, as indicated by (VijayKumar et al., 2022) and (Nene, 2018), respectively.

The formulation known as Panchagavya underwent adjustments that followed the technique laid out by Suresh Kumar and his associates. The modification in query entailed fermenting a mixture of fresh cow dung (weighing 5 kg) and clarified butter (also known as ghee and weighing 500 g) derived from cow milk in a 20 L plastic container at room temperature for four days. The blend was agitated twice daily for 20 minutes each time using a wooden rod. While stirring, the mixture was moved clockwise for 10 minutes and then counterclockwise for the remaining 10 minutes. On the fifth day, 3 L of cow urine, 2 L of cow milk, 2 L of cow milk yogurt, 500 g of sugarcane jaggery, 3 L of sugarcane juice, 12 ripe bananas, 3 L of young coconut water, and 100 g of brewer's yeast (Saccharomyces cerevisiae) were included. The contents were further fermented for 15 days and stirred twice daily for 20 minutes each time to ensure proper aeration. (Choudhary et al., 2017) The Lokopakara, an ancient text in the Kannada language, as documented by Chavundarya, contains information regarding the production of organic liquid manure. The formula consists of a combination of cow dung, cow urine, leaves from specific trees and natural extracts from a variety of plants. This particular organic liquid manure is then administered to crops as a means of enhancing both soil fertility and crop health (VijayKumar et al., 2022).

The Upavanavinoda Sarang Adhara, a Sanskrit text, elucidated the methodology of creating botanical extracts for the purpose of controlling pests and diseases. These concoctions comprised unique botanical elements such as leaves, roots and stems that underwent a process to form a highly concentrated solution. These natural insecticides, in the guise of botanical extracts, were utilized to protect crops from infestations and maladies (Merzlaya, 2022).

Table 1. Historical Books on Agriculture and Their References

Sr. No.	Book Name	Year	Reference
1.	Kashyapiyakrishisukti (A Treatise on Agriculture by Kashyapa)	c. 800b CE	(Gulati, 2002))
2.	Lokopakara by Chavundarya in old Kannada	1025 CE	(VijayKumar et al., 2022)
3.	Upavanavinoda (Woodland Garden for Enjoyment) by Sarang Adhara in Sanskrit	c. 1300 CE	(Sadhale & Shah, 1999)
4.	Mrigapakshishashtra (The Science of Animals and Birds) by Hamsadeva in Sanskrit	c. 1300 CE	(Merzlaya, 2022)
5.	Krishi Gita (Agricultural Verses) by Parashurama in Malayalam	1500 CE	(Jidesh, 2018)
6.	Vishvavallabha (Dear to the World: The Science of Plant Life) by Chakrapani Mishra in Sanskrit	1577CE	(Jidesh, 2018)

The Mrigapakshishashtra, a Sanskrit text authored by Hamsadeva, delved into the technique of manufacturing organic fertilizers using animal excrement, plant material and decomposed matter. These ingredients were mixed and subjected to fermentation, resulting in fertilizers rich in essential nutrients (Nene, 2018). These natural fertilizers were employed to enhance the soil's nutrient composition, thereby fostering the cultivation of crops.

Sustainable Agroecology

The fusion of time-tested agricultural wisdom with organic cultivation methods offers a multitude of advantages. Scientific studies have corroborated the efficacy of combining traditional knowledge with modern organic techniques, resulting in demonstrably enhanced agricultural sustainability and productivity (Fig. 1).

Enhanced Soil Health: Traditional agricultural practices, including crop rotation, composting and the application of natural fertilizers, demonstrably enhance soil health. Chavan et al. (2020) attribute this improvement to elevated organic matter content and increased nutrient availability. When these practices are synergistically combined with organic farming principles, they promote the development of a more robust and productive soil ecosystem.

Biodiversity Conservation: Traditional agricultural systems often incorporate mixed cropping and prioritize the conservation of indigenous plant varieties. These practices demonstrably promote on-farm biodiversity, as evidenced by Bhat et al. (2013). The emphasis on biodiversity-friendly practices within organic farming further serves to augment the *in-situ* preservation of plant and animal species.

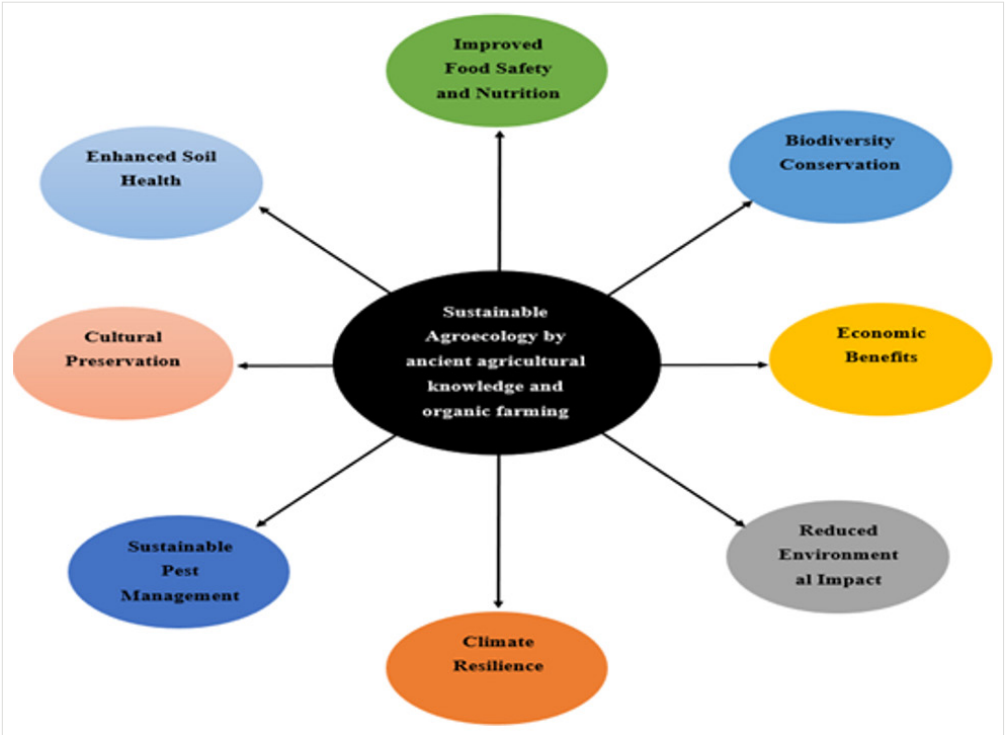

Figure 1. Sustainable agroecology by ancient agricultural knowledge and organic farming

Reduced Environmental Impact: Organic agriculture demonstrably minimizes environmental impact through the reduced utilization of synthetic pesticides and fertilizers. This practice effectively mitigates the dissemination of harmful chemicals into the surrounding environment, leading to a marked decrease in water pollution and soil contamination (Bhat et al., 2013). Furthermore, the integration of traditional agricultural knowledge serves to further amplify the ecologically-sustainable nature of these practices.

Climate Resilience: Specific time-tested agricultural practices, exemplified by hydrological control mechanisms, have demonstrably exhibited the capacity to mitigate climate-related hazards (Tripathi & Mishra, 2016). When strategically integrated with organic agricultural methodologies, these tactics contribute to the enhancement of agricultural resilience and adaptive capacity in the face of a changing climate.

Sustainable Pest Management: Traditional knowledge serves as a valuable repository of sustainable pest management techniques, including the application of herbal extracts and the utilization of beneficial insect populations (Chavan et al., 2020). The synergistic integration of these practices with the pest management principles of organic farming demonstrably reduces reliance on chemical pesticides and fosters the implementation of ecologically-sound pest control strategies.

Cultural Preservation: The integration of time-honored agricultural techniques empowers farmers to act as stewards of their cultural heritage and traditional knowledge, which are often deeply intertwined with the regional ecological landscape (Bhat et al., 2013). The emphasis on sustainability within organic farming aligns seamlessly with the principles of cultural preservation, fostering a holistic approach to agricultural practices.

Economic Benefits: The adoption of sustainable and organic agricultural practices has demonstrably led to increased market opportunities for farmers. Udin (2014) attributes this trend to the growing consumer preference for environmentally-conscious and ethically-produced agricultural products.

Improved Food Safety and Nutrition: The combined application of organic farming techniques and traditional knowledge fosters the production of food free from chemical residues. Research by Foster & Samman (2017) suggests that such food may be richer in certain nutrients. This, in turn, has the potential to contribute to improved health outcomes for consumers.

Case Studies and Examples

The widespread adoption of Vrikshayurveda practices resulted in a remarkable achievement with two-thirds of the region becoming organic tea producers (Ghosh Hajra, 2018). This demonstrates the economic viability and scalability of integrating traditional knowledge with organic farming.

In the Kerala region of India, a consortium of farmers undertook the initiative to regenerate and cultivate indigenous rice varieties, such as Navara, which have constituted an integral component of the region's agricultural heritage for centuries (Dutta, 2019). These cultivators embraced organic farming practices, employing natural fertilizers, composting and herbal pest control techniques in synergy with traditional agricultural knowledge. This approach resulted in the successful preservation of crop biodiversity while simultaneously enhancing soil health and crop resilience.

In Tamil Nadu, India, organic farmers have successfully integrated traditional agricultural knowledge with modern organic practices to develop a holistic pest management system (Roy & Kumari, 2018). This system leverages neem and garlic-based organic repellents alongside the encouragement of natural predators like ladybugs. This approach has demonstrably controlled pest populations, eliminating the requirement for chemical pesticides. Consequently, it has not only minimized the environmental impact but also fostered increased biodiversity on the farms.

Challenges and Limitations

One of the primary challenges associated with incorporating ancient agricultural practices into modern and organic farming relates to the limited scientific validation of their efficacy. While traditional knowledge has been transmitted through generations, there may be a paucity of rigorous scientific studies to corroborate the reliability and effectiveness of these practices (Saha, 2020). This lack of empirical data can pose a challenge for widespread adoption within the scientific agricultural community.

An additional consideration concerns the efficacy of time-tested agricultural practices which were developed under distinct climatic regimes. As the ongoing modifications of climatic patterns continue, it is essential to undertake adaptations to ensure these practices remain aligned with the current environmental conditions (Madan, 2017).

Specific traditional agricultural inputs, such as unique botanical substances or indigenous microbial inoculants, may present challenges due to regional accessibility and commercial availability, thereby hindering their widespread adoption (Divan Baldani et al., 2000).

While organic and traditional agricultural methods often rely on natural pest and disease control mechanisms, they may not provide sufficient protection against emerging or aggressive pest and disease strains. For instance, the efficacy of certain botanical insecticides may be limited against invasive insect species with high resistance. The integration of traditional practices with contemporary pest management strategies, such as the use of biopesticides or resistant crop varieties, is essential for ensuring effective and sustainable crop protection (Tripathi & Mishra, 2016). The preparation of certain traditional agricultural products, such as fermented liquid fertilizers or herbal extracts, can be time-consuming and labor-intensive. Farmers may confront temporal and resource constraints when attempting to implement these practices on a regular basis (Chattopadhyay, 2012). Investigating methods to streamline production processes or exploring community-based production systems could be potential solutions to overcome these limitations.

Future Prospects

The incorporation of traditional ecological knowledge pertaining to pest control, such as the use of neem-based repellents or the introduction of beneficial predator insects within organic farming holds immense potential to reduce reliance on synthetic

pesticides (Chavan et al., 2020). Studying and preserving these practices can empower organic farmers to develop efficacious and environmentally sustainable pest management strategies. Furthermore, traditional knowledge regarding the utilization of autochthonous microbial inoculants derived from practices like using cow dung and herbal extracts offers promising avenues for organic farming. Research suggests that these inoculants can enhance nutrient cycling, improve soil structure and promote overall soil health (Mohotti et al., 2013). Additionally, traditional ecological knowledge on soil detoxification and remediation practices presents a viable solution for addressing soil contamination issues in organic farming, potentially improving both soil health and crop quality (Kone et al., 2023). Traditional herbal remedies used historically to manage plant diseases can inspire the development of eco-friendly and cost-effective biofungicides for organic agriculture (Isman, 2006). Further exploration into the ancient practice of adding charcoal to soil, potentially through the incorporation of biochar, could improve soil fertility, carbon sequestration and water retention (Lehmann et al., 2003). The implementation of ancient practices like mixed cropping and intercropping has been shown to support diverse soil microbial communities, leading to improved nutrient cycling and overall soil health (He et al., 2021).

Conclusion

This review article highlights the significant correlation between organic farming practices and ancient agricultural wisdom in India. By critically examining historical texts, ancient scriptures and archaeological discoveries, a compelling case can be made for the integration of traditional knowledge with organic farming techniques to achieve multifaceted benefits for sustainable agriculture. The utilization of age-old agricultural practices, such as the application of natural fertilizers like Kunapajala and Panchagavya, and herbal extracts for pest control, has demonstrated effectiveness while promoting environmental sustainability. These practices contribute to biodiversity preservation, reduced environmental impact, and advancement of climate resilience. However, it is important to acknowledge that certain challenges and limitations exist when incorporating traditional knowledge, including the need for further scientific validation, adaptation to changing climate conditions and potential resource constraints. Moving forward, coordinated research and development initiatives must prioritize harnessing traditional ecological knowledge for effective pest control, the development of biofertilizers using indigenous microbial inoculants, and the exploration of soil detoxification practices. The integration of biochar and mixed cropping systems can also be further explored within organic farming to enhance soil health and microbial diversity. In conclusion, the convergence of traditional agricultural wisdom and organic farming techniques presents a promising pathway towards contributing to the advancement of sustainable agricultural practices. By merging ancient knowledge with modern organic practices, we can develop resilient and eco-friendly farming systems that address present-day challenges while preserving our agricultural heritage.

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CRediT Authorship Contribution Statement

Rajesh Chaudhary: Conceptualization: Developing the idea for the review paper. **Yogesh Darji:** Literature Search and Data Collection; Conducting comprehensive searches of relevant literature and collecting data from multiple sources; Visualization: Creating figures & tables. **Kush Kachchhava:** Analysis and Synthesis: Analyzing the collected literature, identifying trends, gaps, and key findings, and synthesizing this information to provide a coherent narrative or argument. Writing – Original Draft: Writing the initial draft of the manuscript, organizing the review, drafting sections and ensuring that the narrative flows logically.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Beniwal S. P. S. (2018). Dr Yeshwant Laxman Nene: A Legendary Agricultural Scientist and Pioneer of the Asian Agricultural Heritage. Asian Agri-History Foundation, India 22 (2): 75–97.

Bhat J. A., Kumar M., Bussmann R. W. (2013). Ecological Status and Traditional Knowledge of Medicinal Plants in Kedarnath Wildlife Sanctuary of Garhwal Himalaya, India. J Ethnobiol Ethnomed 9 (1). doi: 10.1186/1746-4269-9-1

Chattopadhyay G. (2012). Use of Vermicomposting Biotechnology for Recycling Organic Wastes in Agriculture. Int J Recycl Org Waste Agricult 1: 8. doi: 10.1186/2251-7715-1-8

Chavan A., Shinde B., Sanap P., Kengare M. (2020). Efficacy of Biopesticides against Thrips (*Scirtothrips dorsalis* Hood) Infesting Chilli (*Capsicum annuum* L.). J Entomol Zool 8 (6): 370–373. doi: 10.22271/j.ento.2020.v8.i6e.7882

Choudhary G. L., Sharma S. K., Singh K. P., Choudhary S., Bazaya B. R. (2017). Effect of Panchagavya on Growth and Yield of Organic Blackgram [*Vigna mungo* (L.) Hepper]. Int J Curr Microbiol App Sci 6 (10): 1627–1632. doi: 10.20546/ijcmas.2017.610.195

Dallapiccola A. L. (1998). Discourse in Early Buddhist Art, Visual Narratives of India. By Vidya Dehejia, pp. ix, 332, 249 figs., New Delhi, Munshiram Manoharlal Publishers, Pvt. Ltd., 1997. J Roy Asiatic Soc 8 (2): 286–287. doi. 10.1017/s1356186300010245

Das T. K., Bandyopadhyay K. K., Ghosh P. K. (2021). Impact of Conservation Agriculture on Soil Health and Crop Productivity under Irrigated Ecosystems. In: Conservation Agriculture: A Sustainable Approach for Soil Health and Food Security (Jayaraman S., Dalal R. C., Patra A. K., Chaudhari S.K., eds), Springer, Singapore, pp. 139–163. doi: 10.1007/978-981-16-0827-8_7

Divan Baldani V. L., Baldani J. I., Döbereiner J. (2000). Inoculation of Rice Plants with the Endophytic Diazotrophs *Herbaspirillum seropedicae* and *Burkholderia* spp. Biol. Fertil Soils 30 (5–6): 485–491. doi. 10.1007/s003740050027

Dutta M. (2019). Forward Linkages for Integrated Farming Practices: A Case Study of Konyoka Multi-Purpose Organic Agriculture Farm Society of Biswanath District of Assam, India. Advance, doi: 10.31124/advance.7803809.v1

Foster M., Samman S. (2017). Implications of a Plant-Based Diet on Zinc Requirements and Nutritional Status. Vegetarian and Plant-Based Diets in Health and Disease Prevention: 683–713. doi: 10.1016/b978-0-12-803968-7.00038-1

Ghosh Hajra N. (2018). Cultivation, Production and Marketing of Organic Tea. Burleigh Dodds Series in Agricultural Science: 485–520. doi. 10.19103/as.2017.0036.21

Gulati A. (2002). Indian Agriculture in a Globalizing World. Am J Agric Econ 84 (3): 754–761. doi: 10.1111/1467-8276.00333

Hammad H. M., Khaliq A., Abbas F., Farhad W., Fahad S., Aslam M., Shah G. M., Nasim W., Mubeen M., Bakhat H. F. (2020). Comparative Effects of Organic and Inorganic Fertilizers on Soil Organic Carbon and Wheat Productivity under Arid Region. Commun Soil Sci Plant Anal 51 (10): 1406–1422. doi: 10.1080/00103624.2020.1763385

He L., Rong H., Li M., Zhang M., Liu S., Yang M., Tong M. (2021). Bacteria Have Different Effects on the Transport Behaviors of Positively and Negatively Charged Microplastics in Porous Media. Journal of Hazardous Materials 415: 125550. doi. 10.1016/j.jhazmat.2021.125550

Isman M. B. (2006). Botanical Insecticides, Deterrents, and Repellents in Modern Agriculture and an Increasingly Regulated World. Annu Rev Entomol 51 (1): 45–66. doi: 10.1146/annurev.ento.51.110104.151146

Jidesh C. V. (2018). Report on the Impact of Asian Agri History Foundation (AAHF) in Popularizing Vrikshayurveda in Kerala, with Special Emphasis to Kannur District, Kerala, India. Asian Agri-History 22 (2): 138–141. doi. 10.18311/aah/2018/v22i2/20884

Kone B., Guety T., Bongoua-Devisme A., Aminata K., Ladji K., Brahima C. (2023). Improvement of Soil Biology and Rice Yield in Peat Land Ecology Using Aqueous Extract of *Costus Afer*: Soil Regenerative Agriculture under Rice Cropping. J Ecol & Nat Res 7 (2): 000337. doi: 10.23880/jenr-16000337

Kumar A., Chandel N., Barkha, (2024). Organic Farming vs. Integrated Nutrient Management: A Comparative Review of Agricultural Productivity and Sustainability. International J Plant Soil Sci 36 (6): 460–473. doi: 10.9734/ijpss/2024/v36i64648

Lehmann J., Pereira da Silva Jr. J., Steiner C., Nehls T., Zech W., Glaser, B. (2003). Plant and Soil 249 (2): 343–357. doi: 10.1023/a:1022833116184

Madan N. (2017). Integrating Farmer's Traditional Knowledge and Practices into Climate Change Sectoral Development Planning: Case Studies from India. In: Climate Change Research at Universities (Filho W. L., ed.), Springer, pp. 3–18.

Maharjan S. K. (2019). Climate-Smart Agriculture (CSA): A Review and Analysis of Policies, Practices and Local Indicators in Nepalese Context (preprint). doi. 10.20944/preprints201909.0257.v1

Merzlaya G. E. (2022). Agroecological Efficiency of Traditional and New Organic Fertilizers. Russ Agric Sci 48 (6): 499–503. doi. 10.3103/s1068367422060106

Mohotti K. M., Chithrapala N. H. M. S., Subasinghe, S. (2013). Elevation of Earthworm Biomass by Organic Cultivation Practices. Long-Term Evidence from Tea Soils. Proceedings of International Forestry and Environment Symposium. doi. 10.31357/fesympo.v0i0.1726

Nene Y. L. (2018). The Concept and Formulation of Kunapajala, the World's Oldest Fermented Liquid Organic Manure. Asian Agri-History 22 (1): 8–14. doi. 10.18311/aah/2018/v22i1/18292

Newton M. (1983). Biochemistry and Physiology of Herbicide Action. Agric. Ecosyst Environ 10 (3): 312–314. doi: 10.1016/0167-8809(83)90050-6

Roy D., Kumari S. (2018). Social Actors in Traditional Tank Rehabilitation: A Case Study of Tamil Nadu (India). Sustain. Water Resour. Manag 5 (2): 587–597. doi: 10.1007/s40899-018-0221-0

Sadhale Y., Shah J. C. (1999). Stabilization of Insulin against Agitation-Induced Aggregation by the GMO Cubic Phase Gel. Int J Pharm 191 (1): 51–64. doi: 10.1016/s0378-5173(99)00288-4

Saha P. (2020). Vermicompost a Cost Effective and Eco-Friendly Component of Organic Farming. Biological Sciences: Impacts on Modern Civilization, Current and Future Challenges. https://doi.org/10.30954/ndp.bio.2020.30

Tripathi A. K., Mishra S. (2016). Biotechnological Approaches. Ecofriendly Pest Management for Food Security: 685–701. doi: 10.1016/b978-0-12-803265-7.00022-1

Turrill W. B., Merrill E. D. (1947). Plant Life of the Pacific World. Kew Bulletin 2 (2): 134. doi. 10.2307/4109212

Twarog S. (2006). Organic Agriculture: A Trade and Sustainable Development Opportunity for Developing Countries. Trade and Environment Review 2006: 141–223. doi: 10.18356/6ad7c431-en

Udin N. (2014). Organic Farming Impact on Sustainable Livelihoods of Marginal Farmers in Shimoga District of Karnataka. Am J Rural Dev 2 (4): 81–88. doi: 10.12691/ajrd-2-4-4

VijayKumar L., Patil S. U., Shivanna B., Kitturmath M. S. (2022). Hypersensitive Response and Induced Resistance in Rice Gene Differentials against Biotype 1 of Asian Rice Gall Midge, *Orseolia oryzae* at Mandya, Karnataka. Rice Res. Open Access 15 (1). doi: 10.58297/mjyg3539

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