

Modern Tools and Advanced Techniques for Promoting Sustainable Sericulture: A Review

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ABSTRACT

Sericulture is an essential agro-based livelihood activity that contributes significantly to rural folk in income generation, and the production of natural silk. It plays a crucial role in strengthening the rural economy in many developing countries, like India. However, conventional sericulture practices often face several constraint such as frequent disease outbreaks, fluctuations in environmental conditions, limited mulberry leaf productivity, and inadequate farm management practices during rearing of silkworm. These challenges may adversely influence silkworm growth, cocoon yield, and the overall quality of silk. Therefore, the introduction of modern tools and improved techniques has become essential to enhance productivity and ensure the longitive sustainability of the sericulture sector. Recent developments in mulberry cultivation have focused on the use of improved varieties, scientific nutrient management, and efficient irrigation practices to increase both leaf yield and quality. High-yielding and disease-tolerant silkworm hybrids have also been developed to improve cocoon production and adaptability to different environmental conditions. In addition, the adoption of scientific rearing methods has contributed to better silkworm health and performance. Modern technologies such as environmental monitoring devices, temperature and humidity control systems, and advanced rearing appliances help maintain optimal conditions for silkworm growth and development. These technological interventions reduce stress in silkworms, improve larval survival, and enhance cocoon quality. Furthermore, improved feeding management, hygienic rearing conditions, and effective disease prevention strategies have become integral components of modern sericulture practices. The use of disinfectants, systematic rearing schedules, and better farm management techniques significantly minimizes larval mortality and increases cocoon yield. In recent years, greater emphasis has also been placed on eco-friendly and sustainable approaches, including the use of organic inputs, integrated disease management, and resource-efficient cultivation practices. Such approaches help reduce environmental impacts while maintaining productivity and farm profitability. Overall, the integration of innovative tools, advanced technologies, and sustainable management practices is transforming traditional sericulture into a more efficient and

resilient production system. These developments not only enhance cocoon productivity and silk quality but also support the socio-economic stability of farmers engaged in sericulture. Promoting modern tools and techniques in sericulture is therefore essential for strengthening the industry and meeting the growing global demand for high-quality silk.

Keywords: Sericulture, Sustainable sericulture, Silkworm rearing, Mulberry cultivation, Modern technology, Cocoon production.

INTRODUCTION

Sericulture, one of the oldest agro-based industries in the world, has gradually evolved into a scientifically managed enterprise that provides sustainable living opportunities to millions of rural family (Krishnaswami, 1978). It represents an unparalleled integration of agriculture and industry, involving the cultivation of mulberry (*Morus alba*) and the rearing of silkworm (*Bombyx mori* L.) for the production of natural silk (Datta, 1984). Owing to its labour-intensive nature, sericulture generates substantial employment, particularly for women and small farmers, thereby playing a vital role in rural development and poverty alleviation. India is among the leading silk-producing countries in the world, supported by its different agro-climatic conditions that are highly favourable for sericulture. Nevertheless, its vast potential, productivity levels in many regions remain suboptimal due to a combination of environmental, biological, and management-related constraints (Rahmathulla, 2012). Among these, fluctuations in temperature and relative humidity are critical factors that directly influence of silkworm growth, development, and survival, often resulting in reduced cocoon yield and inferior silk quality (Horie, 1995). Furthermore, the silkworm diseases such as grasserie, flacherie, pebrine, and muscardine continues to pose serious challenges, frequently leading to substantial economic losses for farmers (Benchamin & Jolly, 1986). The situation is further intensified by poor mulberry leaf quality arising from inadequate nutrient management and inefficient irrigation practices, which negatively impact larval growth and cocoon production (Reddy & Sannappa, 2010). In addition, the persistence of traditional rearing methods, characterized by poor hygiene, improper feeding practices, and lack of scientific management, significantly limits overall productivity and efficiency (Central Silk Board, 2015). In order to address these challenges, the

adoption of modern tools and advanced techniques has become imperative. These innovations aim to enhance productivity, improve operational efficiency, and ensure the long-term sustainability of sericulture systems

Constraints in Conventional Sericulture

Sericulture productivity is highly sensitive to environmental conditions, which play a decisive role in the growth and development of silkworms. Fluctuations in temperature and relative humidity can severely disrupt silkworm metabolism, feeding behaviour, and physiological processes, ultimately leading to poor larval performance and reduced cocoon yield (FAO, 2010). In tropical regions, where climatic variability is high, maintaining optimal rearing conditions remains a major challenge for farmers. In addition to environmental constraints, disease incidence continues to be a critical limiting factor in sericulture, with various pathogens causing substantial crop losses and economic damage. Furthermore, low mulberry productivity and poor leaf quality, often resulting from inadequate nutrient management and inefficient cultivation practices, negatively impact silkworm nutrition and cocoon characteristics. The situation is further compounded by limited awareness, lack of technical knowledge, and restricted access to modern technologies among farmers, which collectively hinder the adoption of improved practices and contribute to persistently low productivity levels (Sarkar, 1993).

Advances in Mulberry Cultivation

Improved Mulberry Varieties

The development of high-yielding and stress-tolerant mulberry varieties such as V1, S36, and G4 has significantly enhanced leaf productivity and nutritional quality. These improved varieties exhibit better adaptability to diverse agro-climatic conditions, higher

biomass production, and improved resistance to pests and diseases. As a result, they provide a consistent and nutritionally rich food source for silkworms, which is essential for optimal larval growth, cocoon development, and silk quality.

Integrated Nutrient Management

Integrated nutrient management plays a crucial role in sustaining soil fertility and improving mulberry yield. The combined application of organic manures, chemical fertilizers, and bio fertilizers ensures balanced nutrient availability and enhances soil health. Organic inputs improve soil structure and microbial activity, while inorganic fertilizers supply essential nutrients required for rapid plant growth. Bio fertilizers further enhance nutrient uptake efficiency, leading to improved leaf quality and increased productivity in a sustainable manner (Sengupta, 2002).

Water Management

Efficient water management is essential for achieving optimal mulberry growth and ensuring sustainable cultivation. The adoption of modern irrigation techniques such as drip and sprinkler systems significantly improves water-use efficiency by delivering precise amounts of water directly to the root zone. These methods reduce water wastage, enhance nutrient absorption, and promote uniform plant growth. Moreover, they are particularly beneficial in water-scarce regions, contributing to sustainable mulberry cultivation and consistent leaf production (FAO, 2013).

Advances in Silkworm Rearing

Improved Silkworm Hybrids

The development of high-yielding and disease-resistant silkworm hybrids has played a crucial role in enhancing cocoon productivity and overall rearing efficiency. These improved hybrids exhibit superior traits such as faster growth rate, better feed conversion efficiency, enhanced tolerance to environmental stress, and increased resistance to common silkworm diseases. As a result, they contribute to higher cocoon yield, improved shell weight, and better silk quality, thereby increasing the economic returns to farmers.

Scientific Rearing Practices

The adoption of scientific rearing practices has significantly improved silkworm health, survival, and

performance. Key practices include maintaining optimal spacing to avoid overcrowding, regular bed cleaning to ensure hygienic conditions, and stage-specific management tailored to the different larval instars. Additionally, systematic feeding schedules and proper environmental regulation further enhance larval growth and development. These scientifically managed practices reduce stress, minimize disease incidence, and ultimately lead to improved cocoon quality and higher productivity.

Modern Tools and Technology

Modern tools and technologies have significantly transformed sericulture by enhancing precision, efficiency, and overall productivity. The integration of advanced technological interventions has enabled better control over rearing conditions and improved management practices. Environmental monitoring systems equipped with digital sensors play a crucial role in continuously tracking key parameters such as temperature and relative humidity in real time. These systems enable farmers to maintain optimal environmental conditions essential for silkworm growth and development, thereby reducing stress and improving larval survival and cocoon quality (FAO, 2010). In addition, climate control devices, including humidifiers, heaters, and automated regulation systems, help maintain a stable microclimate within rearing houses, ensuring consistency across different developmental stages.

Furthermore, the use of advanced rearing appliances such as rotary montages, plastic rearing trays, and automated feeding systems has greatly improved operational efficiency. These technologies reduce labour requirements, enhance hygiene, and ensure uniformity in rearing practices, ultimately leading to higher cocoon yield and improved silk quality (Govindan, 2016). The integration of smart technologies such as the Internet of Things (IoT) and data analytics further strengthens sericulture by enabling real-time monitoring, predictive analysis, and informed decision-making, thereby supporting sustainable and precision-based production systems.

Disease Management

Effective disease management is a critical component for achieving successful and sustainable sericulture. The implementation of strict hygienic practices, including regular disinfection of rearing houses, equipment, and

appliances, plays a vital role in reducing pathogen load and preventing the spread of infections. In addition, the adoption of Integrated Disease Management (IDM) provides a comprehensive and systematic approach to disease control. IDM integrates preventive measures, biological control agents, and the judicious use of chemical disinfectants to effectively manage silkworm diseases. This approach not only minimizes crop losses but also ensures healthier silkworm growth and improved cocoon quality.

Sustainable Sericulture

Organic Practices

The adoption of organic practices in sericulture has gained considerable importance in recent years due to increasing environmental concerns. The use of organic fertilizers, bio-inputs, and eco-friendly disinfectants reduces environmental pollution and enhances soil fertility and biological activity. These practices contribute to the production of high-quality mulberry leaves while maintaining ecological balance (Narayanaswamy, 2015).

Resource Efficiency

Efficient utilization of natural resources is essential for sustainable sericulture. The adoption of water-saving irrigation methods, balanced nutrient management, and recycling of farm waste materials helps reduce input costs and environmental impact. Such practices improve overall farm efficiency and support long-term sustainability of sericulture systems.

Climate Resilience

Climate-resilient sericulture practices are increasingly important in the face of changing environmental conditions. The use of stress-tolerant mulberry varieties, improved silkworm hybrids, and adaptive rearing strategies helps mitigate the adverse effects of temperature and humidity fluctuations. These approaches ensure stable production and reduce risks associated with climate variability.

Impact of Modern Techniques

The adoption of modern tools and advanced techniques has brought remarkable improvements in sericulture productivity and efficiency. These innovations have resulted in increased cocoon yield, improved shell ratio, and enhanced silk quality, reflecting better biological

performance of silkworms. Furthermore, the implementation of advanced technologies and scientific management practices has significantly reduced larval mortality and production risks. As a result, farmers experience higher income levels, improved economic stability, and enhanced livelihood security. Overall, modern sericulture practices have strengthened the sustainability and resilience of the industry, making it more competitive and economically viable (Ramesh, 2019).

Future Prospects

The future of sericulture is poised for significant transformation with the integration of emerging technologies such as artificial intelligence, biotechnology, precision farming, and digital monitoring systems. These innovations offer immense potential to enhance productivity, improve resource-use efficiency, and ensure sustainability in sericulture production systems (Venkatesh, 2020). Artificial intelligence and data analytics can enable predictive decision-making by analysing environmental conditions, disease patterns, and crop performance, thereby Promoting utilization of silkworm as model organism in scientific studies. Advances in biotechnology, including the development of genetically improved silkworm hybrids and stress-tolerant mulberry varieties, are expected to further strengthen resilience against climatic and biological constraints. Precision farming techniques, supported by sensor-based monitoring and automated control systems, will facilitate real-time management of temperature, humidity, and feeding schedules, ensuring ideal conditions for silkworm growth. In addition, the adoption of smart sericulture systems integrated with IoT platforms will enable remote monitoring, reduce labour dependency, and enhance operational efficiency (Central Silk Board, 2020). Collectively, these technological advancements are likely to revolutionize the sericulture sector, making it more resilient, economically viable, and environmentally sustainable in the coming decades.

CONCLUSION

Modern tools and advanced techniques have profoundly transformed sericulture into a highly productive, efficient, and sustainable agro-based enterprise. Technological

advancements in mulberry cultivation, silkworm breeding, precision rearing, and integrated disease management have significantly enhanced cocoon yield, silk quality, and overall farm efficiency. The adoption of environmental control systems and smart monitoring technologies has enabled the maintenance of optimal rearing conditions, thereby minimizing stress and reducing larval mortality. Furthermore, the integration of eco-friendly and resource-efficient practices has strengthened environmental sustainability and ensured long-term viability of the industry. Collectively, these innovations have not only improved economic returns for farmers but also increased the resilience of sericulture systems against climatic and biological challenges. Therefore, the widespread adoption of modern technologies and sustainable approaches is essential for advancing sericulture as a competitive, resilient, and future-ready agro-industrial sector.

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