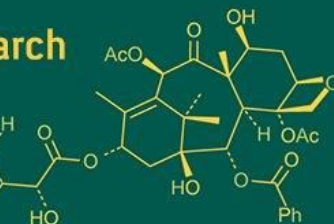


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Role of climate resilient sericulture practices in adapting to environmental variability

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Abstract

Sericulture is an important agro-based rural industry that plays a significant role in employment generation and income support for farming communities. However, the productivity and sustainability of sericulture are highly influenced by climatic conditions such as temperature, humidity, rainfall patterns, and seasonal variability. Recent changes in global climate have increased environmental uncertainties, posing serious challenges to mulberry cultivation and silkworm rearing. Climate-induced stresses can affect mulberry leaf quality, silkworm growth, cocoon yield, and overall silk production. Climate-resilient sericulture practices have therefore become essential for sustaining the industry under changing environmental conditions. These practices include the development of stress-tolerant silkworm breeds, improved mulberry varieties, efficient water management, controlled rearing technologies, and integrated pest and disease management strategies. The adoption of these adaptive measures can help minimize the adverse effects of climate variability while enhancing productivity and resource efficiency. This review highlights the role of climate-resilient sericulture practices in improving the adaptability of sericulture systems to environmental variability. It also emphasizes the importance of sustainable management approaches that support stable silk production and strengthen the livelihood security of farmers dependent on sericulture.

Keywords: Sericulture, climate resilience, mulberry cultivation, silkworm rearing, environmental variability, sustainable agriculture

1. Introduction

Sericulture, the cultivation of silkworms for the production of silk, is an important agro-based industry that contributes significantly to rural employment, income generation, and economic development in many countries. The process of sericulture involves several interconnected activities, including mulberry cultivation, silkworm rearing, cocoon production, silk reeling, and weaving [1-2]. Among these stages, mulberry cultivation and silkworm rearing are highly dependent on environmental conditions, making the sericulture sector particularly vulnerable to climatic variations.

The mulberry silkworm (*Bombyx mori*) requires a narrow range of temperature and humidity conditions for optimal growth and cocoon production. Ideal environmental conditions for silkworm rearing generally range between 23-28 °C temperature and 70-85% relative humidity. Any deviation from these conditions can adversely affect silkworm health, feeding efficiency, larval growth, and cocoon formation. Similarly, mulberry plants require suitable climatic conditions, soil fertility, and adequate water supply for producing high-quality leaves that serve as the primary food source for silkworms [3-4]. In recent years, global climate change has caused significant alterations in environmental conditions, including rising temperatures, erratic rainfall patterns, prolonged droughts, and extreme weather events. These changes have introduced new challenges for sericulture farmers, as they directly influence mulberry productivity, increase the incidence of pests and diseases, and reduce the survival rate of silkworms. Environmental stress can also affect the quality of cocoons, thereby lowering silk yield and economic returns for farmers, these challenges, the concept of climate-resilient sericulture has emerged as an effective strategy for maintaining sustainable silk production under changing climatic conditions. Climate-resilient practices focus on improving the adaptability of sericulture systems by integrating improved technologies, climate-tolerant silkworm breeds, enhanced mulberry cultivation methods, and better farm management practices [5].

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These strategies help reduce the negative impacts of climate variability while ensuring stable cocoon production. Therefore, the adoption of climate-resilient sericulture practices is essential not only for maintaining productivity but also for safeguarding the livelihoods of millions of rural households that depend on sericulture as a primary or supplementary source of income.

2. Impact of Environmental Variability on Sericulture

Environmental variability plays a crucial role in determining the productivity and sustainability of sericulture systems. Changes in climatic factors such as temperature, humidity, rainfall, and seasonal cycles can influence both mulberry cultivation and silkworm rearing [6]. Since mulberry leaves are the sole food source for silkworms, any environmental factor affecting mulberry growth ultimately affects silkworm performance and cocoon production.

Temperature is one of the most critical environmental factors influencing sericulture. High temperatures can lead to heat stress in silkworms, resulting in reduced appetite, slower growth rates, and increased mortality. On the other hand, extremely low temperatures may delay larval development and prolong the rearing cycle. Similarly, fluctuations in humidity can influence the feeding behavior and physiological functions of silkworms, ultimately affecting cocoon quality [7]. Rainfall patterns also have a significant impact on mulberry cultivation. Excessive rainfall may cause waterlogging in mulberry fields, leading to root damage and reduced leaf yield. In contrast, prolonged drought conditions can reduce soil moisture, resulting in poor plant growth and lower leaf production. Poor-quality mulberry leaves contain reduced nutrient content, which can negatively affect the growth and development of silkworm larvae.

Environmental variability can also increase the incidence of diseases and pests affecting both mulberry plants and silkworms [8]. High humidity and warm conditions provide favorable environments for the development of pathogens responsible for diseases such as grasserie, flacherie, muscardine, and pebrine in silkworms. Similarly, mulberry plants are vulnerable to various pests and fungal diseases that can reduce leaf yield and quality [9]. Another important challenge associated with climate variability is the disruption of traditional sericulture seasons. Farmers typically plan their silkworm rearing cycles based on predictable seasonal patterns. However, irregular weather conditions may affect mulberry leaf availability and the timing of silkworm rearing, leading to production losses. Therefore, environmental variability poses significant threats to the sustainability of sericulture. Without proper adaptive strategies, these climatic challenges can lead to reduced cocoon yield, poor silk quality, and economic losses for sericulture farmers.

3. Climate-Resilient Practices in Sericulture

To overcome the challenges posed by climate change and environmental variability, several climate-resilient sericulture practices have been developed and promoted [10]. These practices aim to enhance the adaptability and sustainability of sericulture systems while minimizing the risks associated with changing environmental conditions.

3.1 Development of Climate-Tolerant Silkworm Breeds

One of the most important strategies for improving climate resilience in sericulture is the development of silkworm breeds that can tolerate environmental stress. Researchers have developed improved hybrid silkworm varieties that exhibit higher tolerance to temperature fluctuations, humidity changes, and disease infections.

These improved breeds possess better adaptability to local environmental conditions and demonstrate enhanced growth performance, survival rates, and cocoon productivity. The use of such climate-tolerant silkworm strains enables farmers to maintain stable production even under unfavorable climatic conditions.

3.2 Improved Mulberry Cultivation Practices

Mulberry cultivation forms the backbone of sericulture, and improving mulberry production is essential for climate resilience [11]. Climate-resilient mulberry cultivation involves the use of drought-tolerant and high-yielding mulberry varieties, proper soil management, and efficient irrigation techniques. Practices such as mulching, organic manure application, and crop rotation can improve soil moisture retention and soil fertility, thereby enhancing mulberry plant growth even under water-limited conditions. Additionally, the use of improved planting techniques and appropriate pruning methods can increase leaf yield and improve leaf quality.

3.3 Water Conservation and Irrigation Management

Water scarcity is becoming an increasingly serious challenge for sericulture farmers in many regions. Efficient water management practices such as drip irrigation, rainwater harvesting, and mulching can help conserve water while ensuring adequate moisture supply for mulberry plants. Drip irrigation systems deliver water directly to the plant roots, reducing water wastage and improving irrigation efficiency. Rainwater harvesting techniques can also help farmers store water during rainy seasons for use during dry periods.

3.4 Improved Silkworm Rearing Infrastructure

The development of improved silkworm rearing facilities can significantly reduce the impact of climate variability. Modern rearing houses equipped with temperature and humidity control systems help maintain optimal environmental conditions for silkworm growth. Proper ventilation, sanitation, and regular disinfection of rearing equipment are also essential for preventing disease outbreaks [12]. The use of improved rearing appliances and hygienic practices can enhance cocoon quality and increase productivity.

3.5 Integrated Pest and Disease Management

Integrated pest and disease management strategies are essential for minimizing losses caused by pests and pathogens. These strategies combine biological control, cultural practices, and minimal chemical interventions to control pests and diseases affecting mulberry plants and silkworms. Regular monitoring of fields, early detection of disease symptoms, and the use of resistant varieties can help prevent large-scale outbreaks. Biological control agents and environmentally friendly pest management practices can further enhance the sustainability of sericulture systems.

Table 1: Major Climate Factors Affecting Sericulture and Their Impacts

Climate Factor	Impact on Mulberry Cultivation	Impact on Silkworm Rearing	Overall Effect on Silk Production
High Temperature	Reduces leaf moisture and nutrient content	Causes heat stress, reduced feeding, and higher larval mortality	Lower cocoon yield and poor silk quality
Low Temperature	Slows mulberry plant growth	Delays larval development and cocoon formation	Longer production cycles
Irregular Rainfall	Waterlogging or drought affecting plant growth	Alters rearing seasons and humidity conditions	Reduced leaf availability and cocoon productivity
High Humidity	Encourages fungal diseases in mulberry plants	Increases incidence of silkworm diseases such as muscardine and flacherie	Higher production losses
Drought	Decreases leaf yield and plant vigor	Reduces nutrition for silkworm larvae	Lower cocoon weight and silk output
Extreme Weather Events	Damage to mulberry plantations	Disruption of rearing houses and silkworm mortality	Severe production decline

Table 2: Climate-Resilient Sericulture Practices and Their Benefits

Climate-Resilient Practice	Description	Benefits for Sericulture
Climate-tolerant silkworm breeds	Development of hybrid strains resistant to temperature stress and diseases	Improved survival rate and stable cocoon production
Improved mulberry varieties	Use of drought-tolerant and high-yielding mulberry cultivars	Better leaf quality and increased silkworm nutrition
Drip irrigation and water management	Efficient irrigation methods and rainwater harvesting	Water conservation and improved mulberry productivity
Improved rearing infrastructure	Rearing houses with temperature and humidity control	Stable environmental conditions for silkworm growth
Integrated pest and disease management	Combination of biological control, monitoring, and hygienic practices	Reduced pest outbreaks and lower chemical usage
Soil fertility management	Use of organic manure, mulching, and biofertilizers	Improved soil health and sustainable mulberry production

4. Benefits of Climate-Resilient Sericulture Practices

The adoption of climate-resilient practices in sericulture provides several ecological, economic, and social benefits. These practices help farmers adapt to changing climatic conditions while maintaining sustainable silk production. As environmental variability continues to affect agricultural systems globally, climate-resilient strategies play a crucial role in reducing vulnerability and improving the overall efficiency of sericulture. One of the major benefits of climate-resilient sericulture is enhanced productivity and stability of cocoon yield. Improved mulberry varieties and climate-tolerant silkworm breeds enable farmers to maintain production levels even under fluctuating environmental conditions. These improved varieties are often capable of withstanding higher temperatures, limited water availability, and disease pressure, which helps ensure consistent cocoon production^[13]. Climate-resilient practices also contribute to improved mulberry leaf quality, which directly affects silkworm growth and silk yield. Techniques such as proper irrigation management, mulching, and organic nutrient management enhance soil fertility and moisture retention. As a result, mulberry plants produce nutritious leaves that support better silkworm health and higher cocoon quality. Another important benefit is reduced vulnerability to pests and diseases. Integrated pest and disease management strategies help control outbreaks that may arise due to favorable environmental conditions for pathogens. The use of biological control agents, resistant varieties, and proper sanitation practices reduces the reliance on chemical pesticides, thereby promoting environmentally sustainable sericulture. Climate-resilient sericulture also promotes efficient resource utilization. Water conservation techniques such as drip irrigation and rainwater harvesting help optimize water use, particularly in regions facing water scarcity. Similarly, organic fertilizers and sustainable soil

management practices improve long-term soil health and productivity^[14-20]. From a socio-economic perspective, these practices help strengthen the livelihoods of rural communities involved in sericulture. The industry provides employment opportunities in rural areas, especially for smallholder farmers and women. By ensuring stable cocoon production and improving silk quality, climate-resilient strategies help increase farmers' income and reduce economic risks associated with climate change. Furthermore, the adoption of sustainable sericulture practices contributes to environmental conservation by reducing soil degradation, conserving water resources, and minimizing chemical inputs. These practices support the long-term sustainability of the sericulture sector and align with broader goals of climate-smart agriculture.

5. Conclusion

Sericulture remains an important agro-based industry that supports the livelihoods of millions of rural households worldwide. However, the sector is highly sensitive to climatic conditions, and environmental variability caused by climate change has emerged as a significant challenge for sustainable silk production. Fluctuations in temperature, humidity, and rainfall patterns can adversely affect mulberry cultivation, silkworm health, and cocoon productivity, ultimately leading to economic losses for farmers. Climate-resilient sericulture practices offer a practical and sustainable solution to these challenges. Strategies such as the development of climate-tolerant silkworm breeds, improved mulberry cultivation techniques, efficient water management, modern rearing infrastructure, and integrated pest and disease management can significantly enhance the adaptability of sericulture systems to changing environmental conditions. The adoption of these practices not only helps mitigate the adverse impacts of climate

variability but also improves productivity, resource efficiency, and environmental sustainability. In addition, climate-resilient sericulture strengthens rural livelihoods by ensuring stable income opportunities for farmers and promoting sustainable agricultural development. To further enhance the resilience of the sericulture sector, it is important to promote research, farmer training, and extension services that facilitate the adoption of improved technologies and management practices. Government support, policy initiatives, and investment in climate-smart agricultural innovations will also play a crucial role in strengthening the adaptability of sericulture systems, integrating climate-resilient practices into sericulture production systems is essential for safeguarding the future of the silk industry and ensuring sustainable rural development in the face of ongoing environmental changes.

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