STM JOURNALS

International Journal of
Insects

Volume 1, Issue 2, 2024
July–December
DOI (Journal): 10.37591/IJI

https://journals.stmjournals.com/iji

Review IJI

Silkworm Growth and Silk Yield under Changing Climatic Conditions: Challenges and Adaptations

Susikaran S.[1,*], Karthick Mani Bharathi B.[2], Allwin Loveson[3], V. Vasanth,[4]
S. Navanneetha Krishnan[5], Kiruthika C.[6]

Abstract

Climate change is emerging as a critical factor affecting agriculture and sericulture industries worldwide. Rising global temperatures, shifting rainfall patterns, and the growing frequency of extreme weather events present ever challenges to the growth and productivity of silkworms (Bombyx mori L.). Silkworms are extremely sensitive to environmental conditions like temperature, humidity, and photoperiod, all altered by climate change. Higher temperatures can accelerate silkworm metabolism, reduce silk yield, and increase susceptibility to diseases, and lead to developmental abnormalities. In addition, changes in rainfall patterns and shifts in soil moisture affect the growth and nutritional quality of mulberry's plant (Morus sp.), the primary food source for silkworms. As a result, poor-quality mulberry leaves led to reduced silkworm health and lower silk output. Increased disease incidence, pest pressure, and water scarcity further compounded by climate variability will continue to threaten the sustainability of the sericulture industry. However, recent research highlights adaptive strategies, such as breeding climate-resilient silkworm varieties thereby improving mulberry cultivation practices, implementing integrated pest management (IPM) and using controlled rearing environments as potential mitigations. This abstract summarizes the critical effects of climate change on silkworm biology, mulberry plantations, and silk production while also emphasizing the need for continued research, innovation, and policy intervention to secure the future of the sericulture industry in a rapidly changing climate.

Keywords: Climate change, sericulture, silk yield, silkworm biology, silkworm health

***Author for Correspondence**
Susikaran S.
E-mail: susi.agri@gmail.com

[1]Assistant Professor, Directorate of Open and Distance Learning, Tamil Nadu Agricultural University Coimbatore, Tamil Nadu, India
[2,6]Student, Department of Sericulture, Forest College and Research Institute, Tamil Nadu Agricultural University, Mettupalayam, Tamil Nadu, India
[3]Associate Professor, Department of Agricultural Entomology, VOCACRI, Tamil Nadu Agricultural University, Killikulam, Tamil Nadu, India
[4,5]Research Scholar, Department of Sericulture Forest College and Research Institute, Tamil Nadu Agricultural University, Mettupalayam, Tamil Nadu, India

Received Date: October 02, 2024
Accepted Date: October 08, 2024
Published Date: October 22, 2024

Citation: Susikaran S., Karthick Mani Bharathi B., Allwin Loveson, V. Vasanth, S. Navanneetha Krishnan, Kiruthika C. Silkworm Growth and Silk Yield under Changing Climatic Conditions: Challenges and Adaptations. International Journal of Insects. 2024; 1(2): 1–5p.

INTRODUCTION

Sericulture has been an integral part of human history for thousands of years with the domesticated silkworm, *Bombyx mori* L. being a key player in silk production. The silk industry holds economic significance, particularly in countries like China, India, and Japan. Silk, a protein fiber with many layers of sericin and fibroin is produced by silkworms as they spin their cocoons. The quality and quantity of silk produced depend on a variety of factors, including the health of the silkworm The environmental conditions in which it is reared closely influence it [1]. Climate change is driven by anthropogenic activities, such as deforestation, industrial emissions, and land use changes that are causing global temperatures to rise. As a result, ecosystems across the globe are undergoing drastic changes. These shifts can profoundly affect the life cycle of silkworms, their physiological responses, and ultimately their ability to produce silk. This article aims to discuss the effects of climate change on silkworm growth and productivity using scientific data and insights from recent research [2].

CLIMATE CHANGE AND ITS GLOBAL IMPACTS

Climate change refers to long-term alterations in temperature, precipitation patterns, and atmospheric conditions driven by both natural processes and human activities. The Intergovernmental Panel on Climate Change (IPCC) has projected that the Earth's average temperature could rise by 1.5°C–2°C by 2100. The consequences of these changes are already being observed in the form of rising sea levels, melting ice caps, and more frequent extreme weather events like hurricanes, droughts, and floods. Rising temperatures and changing rainfall patterns can significantly affect agriculture, forestry, water resources, and biodiversity [3]. These changes may lead to shifts in growing seasons, decreased agricultural productivity, and heightened susceptibility to pests and diseases. Sericulture, being dependent on specific environmental conditions, is no exception. The life cycle of silkworms is closely tied to the environment, with light deviations from their optimal temperature and humidity ranges having profound effects on their growth and productivity [4].

BIOLOGY OF THE SILKWORM

Bombyx mori L. undergoes complete metamorphosis, including four distinct life stages: egg, larva (caterpillar), pup, and adult (moth). The larval stage is the most important stage in sericulture as this is when silkworms consume large quantities of mulberry leaves and produce silk proteins, which are then spun into cocoons [5]. The growth and development of silkworms are susceptible to environmental factors, particularly temperature, humidity, and food availability. Optimal growth occurs when silkworms are reared at temperatures between 24°C and 28°C, with relative humidity levels between 70% and 85%. Deviations from these optimal conditions can result in slower growth rates increased susceptibility to diseases and lower silk yield [6].

CLIMATE CHANGE IMPACTS ON MULBERRY PLANTATIONS

Mulberry plants (*Morus* spp.) are the primary food source for silkworms and are critical to the success of the sericulture industry [7]. The growth of mulberry climatic conditions directly influences plants, such as temperature, precipitation, and soil moisture levels [8]. Climate change can negatively impact mulberry production in several ways:

- *Rising temperatures:* Higher temperatures can cause physiological stress in mulberry plants, thereby reducing their leaf yield and quality. Temperature extremes can lead to leaf scorching, wilting, and reduced photosynthesis, which ultimately lowers the nutritional value of the leaves for silkworms.
- *Altered rainfall patterns:* Irregular rainfall can affect mulberry growth by altering soil moisture levels. Extended drought conditions can cause water stress, thereby resulting in reduced leaf size and quality while excessive rainfall can lead to waterlogging, root rot, and a greater susceptibility to diseases [9].
- *Increased CO_2 levels*: Elevated atmospheric carbon dioxide levels can increase the photosynthesis rate in mulberry plants, potentially boosting leaf production. However, this positive effect something may be offset by other factors, such as temperature increases and changes in water availability [10].

DIRECT EFFECTS OF CLIMATE CHANGE ON SILKWORM GROWTH

- *Temperature stress:* Silkworms are poikilothermic organisms whose body temperature relies on the surrounding environmental temperature. When temperatures rise above the optimal range for silkworms, their metabolic rate increases, leading to faster growth and reduced silk production. High temperatures can also cause developmental abnormalities, reduce larval survival rates, and increase the incidence of diseases. Studies have shown that silkworms reared at temperatures above 30°C produce significantly less silk than those reared at optimal temperatures [11].
- *Heat shock proteins:* Silkworms, like other organisms, will produce heat shock proteins (HSPs) in response to temperature stress. These proteins play a crucial role in protecting cells from damage

caused by elevated temperatures. However, the production of HSPs is energetically costly and can divert resources away from silk production. Moreover, prolonged exposure to high temperatures can overwhelm the silkworm's ability to cope with heat stress, thereby leading to reduced growth and productivity.

- *Humidity:* Silkworms require a specific range of humidity levels for optimal growth. Low humidity levels can cause dehydration and impede the moulting process while high humidity can increase the risk of fungal and bacterial infections. Climate change is expected to cause more frequent and intense fluctuations in humidity levels which could negatively impact silkworm health and silk production [12].
- *Photoperiod and seasonality:* Changes in the photoperiod (the duration of daylight) and seasonality due to climate change can disrupt the life cycle of silkworms. Silkworms are highly sensitive to changes in day length, which regulate their diapause (a period of suspended development) and reproduction. Alterations in the timing of seasonal changes can lead to mismatches between the availability of mulberry leaves and the development of silkworms, resulting in lower productivity [13].
- *Disease incidence:* Climate change can also increase the prevalence of diseases in silkworm populations. Higher temperatures and increased humidity can create optimal conditions for the growth, and spread of pathogens including bacteria, viruses, and fungi. Diseases, such as flacherie, muscardine, and grasserie are already major threats to silkworm production, and their incidence is expected to rise with climate change [14].

INDIRECT EFFECTS OF CLIMATE CHANGE ON SILKWORM PRODUCTIVITY

- *Mulberry quality:* As discussed earlier, climate change can reduce the quality and availability of mulberry leaves. Poor-quality leaves can result in slower growth rates, lower silk production, and higher mortality rates in silkworms. The nutritional content of mulberry leaves, especially their levels of protein and carbohydrates, were essential for silk production. Changes in the chemical composition of mulberry leaves due to climate change could have significant repercussions for the silk industry.
- *Pest and predator pressure:* Climate change can also affect the populations of pests and predators that target mulberry plants and silkworms. Rising temperatures and changing rainfall patterns can result in the growth of pest populations, thereby increasing the pressure on both mulberry plants and silkworms. For example, the mulberry pest *Glyphodes pyloalis*, which causes defoliation in mulberry plants, may become more prevalent with rising temperatures. Additionally, predators, such as birds, ants, and parasitic wasps may thrive under changing climatic conditions, posing a threat to silkworm populations [12].
- *Water availability:* Water availability plays a vital role in mulberry cultivation and silkworm rearing. Climate change is expected to intensify water scarcity in many regions, particularly in arid and semi-arid areas. Reduced water availability can negatively impact mulberry growth, thus leading to lower leaf yields and poor-quality leaves. In regions where water is used for silkworm rearing, such as for maintaining humidity levels in rearing rooms, water shortages could further complicate sericulture practices [15].

ADAPTIVE STRATEGIES TO MITIGATE THE IMPACT OF CLIMATE CHANGE

The negative impacts of climate change on silkworm growth and productivity are undeniable. However, several adaptive strategies can help mitigate these effects and ensure the sustainability of the sericulture industry.

- *Breeding climate-resilient silkworm varieties:* One of the most promising strategies is the development of silkworm varieties that are more resilient to temperature and humidity fluctuations. Breeding programs can focus on selecting silkworm strains that produce higher silk yields under suboptimal environmental conditions. Additionally, silkworms that are more resistant to diseases and pests could help reduce losses due to climate change.

- *Improving Mulberry cultivation practices:* It is essential to enhance mulberry cultivation practices to address the challenges of climate change. This includes developing drought-tolerant and heat-resistant mulberry varieties and implementing water-efficient irrigation techniques, such as drip irrigation. Additionally, mulching, agroforestry, and other sustainable land management practices can help enhance soil moisture retention and reduce the vulnerability of mulberry plantations to climate change [16].
- *Optimizing rearing conditions:* Maintaining optimal rearing conditions for silkworms, even in the face of climate variability, is critical. This can be achieved through controlled environment-rearing systems that regulate temperature, humidity, and light conditions. For example, automated climate control systems can help maintain ideal rearing conditions during heat waves or high humidity thus ensuring that silkworms continue growing and producing silk efficiently [17].
- *Integrated Pest Management (IPM):* Adopting integrated pest management practices can help reduce the impact of climate change on pest populations that target silkworms and mulberry plants. Integrated Pest Management (IPM) employs a mix of biological, cultural, and chemical control strategies to regulate pest populations in an environmentally sustainable way. For example, using pheromone traps, natural predators, and bio-pesticides can help control pest populations without harming the environment or silkworms [18].
- *Climate monitoring and early warning systems:* Establishing climate monitoring and early warning systems can help sericulture farmers anticipate and respond to climate-related challenges. By monitoring temperature, humidity, rainfall, and other climatic variables, farmers can make informed decisions about when to plant mulberry trees, when to rear silkworms, and how to protect their crops from extreme weather events. Early warning systems can also help detect the emergence of diseases and pests, allowing for timely interventions [19].

CONCLUSIONS

Climate change presents a significant threat to the sericulture industry, impacting both the growth and productivity of silkworms. Rising temperatures, altered rainfall patterns and increased disease incidence are among the key challenges facing silkworm farmers. However, by adopting adaptive strategies, such as breeding climate-resilient silkworms thereby improving mulberry cultivation practices and implementing climate monitoring systems, the negative impacts of climate change on silkworm production can be mitigated. The future of the silk industry will depend on the ability of farmers, researchers and policymakers to work together to address the challenges posed by climate change. By investing in research and innovation, the sericulture industry can continue to thrive in a changing climate, thus ensuring that this ancient and valuable craft is preserved for future generations.

REFERENCES

1. Bharathi KM, Susikaran S, Vijay S, Vasanth V, Kumar R, Kumar A, et al. A comparative biochemical study of mulberry (*Morus* spp.) mini clones over conventional stem cuttings. Int J Plant Soil Sci. 2024;36(5):975–983. doi: 10.9734/ijpss/2024/v36i54593.
2. Bhat MR, Radha P, Faruk AA, Vas M, Brahma D, Bora NR, et al. Climate change and its impact on sericulture. 2024;9(4):13–25. doi: 10.55126/ijzab.2024.v09.i04.004.
3. Legg S. IPCC, 2021: Climate change 2021-the physical science basis. Interaction. 2021 Dec 1;49(4):44-5.
4. Mishra CB. Effect of temperature on the silk producing potential of silkworm, *Bombyx mori* (Lin) in perspective of climate change. J Exp Zool India. 2018;21(2):1039–1040.
5. Bharathi KM, Susikaran S, Parthiban KT, Vasanth V, Vijay S. Influence of different transplanting days on yield attributes of mini clones under field conditions for *Morus indica* (V1). Madras Agric J. 2024;111(3):1–7.
6. Sujatha GS, Kumar GA, Teja KS, Devi DL, Panda A, Rupali JS, et al. A comprehensive review of the effect and mitigation of climate change on sericulture. Int J Environ Clim Change. 2024;14(7):776–788. doi: 10.9734/ijecc/2024/v14i74317.

7. Bharathi KM, Susikaran S, Parthiban KT, Vasanth V. Effect of auxins on biochemical composition of apical cuttings of mulberry (*Morus indica* L.) using mini clonal technology. Int J Zool Appl Biosci. 2024;9(3):40–45. doi: 10.55126/ijzab.2024.v09.i03.007.
8. Lalitha N, Singha BB, Das B, Choudhury B. Impact of climate change in prospects of Eri silkworm seed production in Assam-A review. Innov Farming. 2020;5(1):10–14.
9. Peng M, Wang G, Zhu S. Cold-stored mulberry leaves affect antioxidant system and silk proteins of silkworm (Bombyx mori) larva. Journal of the Science of Food and Agriculture. 2023 Dec;103(15):7673-82.
10. Gedam PC, Bawaskar DM, Chowdary NB, Venugopal A, Ingale AD. Perception of Tasar silkworm rearers about the climate change impact on the Tasar silk production of Maharashtra. Asian J Agric Ext Econ Sociol. 2023;41(7):153–164. doi: 10.9734/ajaees/2023/v41i71958.
11. Manzoor S, Qayoom K. Impact of climate change on sericulture. Asian Res J Agric. 2024;17(3):107–113. doi: 10.9734/arja/2024/v17i3477.
12. Natikar P, Sasvihalli P, Halugundegowda GR, Sarvamangala HS. Effect of global warming on silk farming: A review. Pharma Innov. 2023;12(3):3714–3729.
13. Maurya P, Goswami M, Nautiyal S, Prakash S, Gupta AK, Sathish A. Resource Flow in Peri-urban Agroecosystem: an Assessment from Circular Economy Perspective. Circular Economy and Sustainability. 2024 Jun;4(2):1093-114.
14. Rahmathulla VK. Management of climatic factors for successful silkworm (*Bombyx mori* L.) crop and higher silk production: A review. Psyche J Entomol. 2012;1:121234. doi: 10.1155/2012/121234.
15. Blaise D, Kranthi KR. Cotton production in India. Cotton production. 2019 Aug 13:193-215..
16. Ram RL, Maji C, Bindroo BB. Impact of climate change on sustainable sericultural development in India. Int J Agric Innov Res. 2016;4(6):1110–1118.
17. Singh RP et al. Climate resilient sericulture: Advances and future prospects. J Seric Res. 2021.
18. Sujatha GS, Kumar GA, Teja KS, Devi DL, Rupali JS, Gautam SK. A Comprehensive Review of the Effect and Mitigation of Climate Change on Sericulture. International Journal of Environment and Climate Change. 2024 Jul 25;14(7):776-88.
19. Gani MN, Ghosh MK. Impact of climate change on agriculture and sericulture. J Entomol Zool Stud. 2018;6(5):426–429.

