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Challenges and Adoption of Bivoltine Hybrid Silkworm Rearing in Karnataka's South-Eastern Dry Zone, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present study explores the adoption of bivoltine hybrid silkworm rearing practices in the South-Eastern Dry Zone of Karnataka, specifically within the Kolar and Chikkaballapur districts. Data collected from thirty sericulturists using a pretested interview schedule, reveal a mixed picture of practice adoption. The adoption levels of recommended practices vary significantly among rearers. While high adoption rates were observed for certain practices, such as the use of recommended mulberry varieties and irrigation techniques, other practices show only moderate adherence.

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Specifically, cent per cent of the sericulturists have adopted the recommended mulberry variety and 93.33% follow suggested irrigation schedules. However, there is only a 60% adoption rate for the use of prescribed fertilizers and pest management practices. The study also highlights several key constraints impacting the adoption of these practices. Major constraints include limited access to quality inputs, insufficient technical knowledge and inadequate extension services. Financial constraints and environmental challenges further exacerbate these issues, affecting the overall effectiveness of sericulture practices. Recommendations to improve adoption levels include enhancing access to quality inputs, enhancing educational and extension services which talking financial obstacles. By implementing these recommendations, it is anticipated that sericulturists in these region will be better equipped to adopt and benefit from advanced silkworm rearing practices, resulting in greater productivity and long-term sustainability in the sericulture sector.

Keywords: Adoption; bivoltine; constraints; rearing; sericulturists; silkworm.

1. INTRODUCTION

Sericulture, often referred to as the "Queen of Textiles," plays an important but overlooked role in the world economy, accounting for less than 0.2% of the global textile market [1]. Despite this modest percentage, sericulture's impact is profound, especially in Asia, where the industry is deeply embedded in the socio-economic fabric of rural communities. In India, sericulture is more than just an economic activity; it is a cornerstone of rural development, offering employment opportunities and supporting livelihoods across the country. The sector's significance is underscored by the recent growth in silk production, with India recording a 6.37% increase in the fiscal year 2023-24, further solidifying its position as one of the world's leading silk producers.

In 2023-24, India’s silk production reached 38,913 metric tons (MT), marking a 6.37% increase from the previous year’s 36,582 MT, achieving 88.4% of the annual target. Notably, bivoltine raw silk production saw a significant rise of 42.60%, from 6,783 MT in 2020-21 to 9,675 MT in 2023-24. This growth is pivotal in reducing raw silk imports and protecting the interests of domestic producers [1].

Karnataka, particularly the southeastern dry zone, emerges as the epicenter of India’s sericulture industry. This region is not only vital for cocoon production but also for the cultivation of mulberry, the primary food source for silkworm, *Bombyx mori* L. The success of sericulture in this area is largely dependent on the adoption of advanced practices, such as the rearing of bivoltine hybrid silkworms, known for their superior silk yield and quality. However, despite the potential benefits, the adoption of these practices varies, influenced by various socio-economic and environmental constraints faced by sericulturists [2]. This research seeks to explore the adoption levels of bivoltine hybrid silkworm rearing practices in Karnataka's southeastern dry zone, focusing light on the challenges and opportunities within this vital segment of the sericulture industry.

2. MATERIALS AND METHODS

The study was carried out in Kolar and Chikkaballapur districts of Karnataka, focused on bivoltine hybrid silkworm rearing practices. Thirty silkworm rearers from fifteen villages were randomly selected *i.e.,* rearers from seven villages of Chikkaballapur and eight from Kolar districts for the study. Data was collected using a pretested interview schedule to ensure accuracy and reliability. The collected data were subjected to statistical analysis, employing mean and standard deviation to interpret the results. This methodology provided valuable insights into the adoption levels and challenges faced by sericulturists in these key regions of Karnataka's sericulture industry.

3. RESULTS AND DISCUSSION

3.1 Adoption of Specific Mulberry Cultivation Practices by Bivoltine Hybrid Silkworm Rearers

The adoption levels of various mulberry cultivation practices were presented in Table 1. The high levels of adoption for certain practices, such as mulberry variety (100%) and irrigation management (93.33%), reflect an overall positive trend. However, lower adoption rates in composting (20%) and intercropping (23.33%) indicate areas for improvement.

The study reveals varied adoption rates of recommended mulberry cultivation practices

among silkworm rearers. The recommended mulberry variety (V-1) is universally adopted, with a cent per cent adoption rate, reflecting its known benefits in cocoon production and disease resistance. This finding is consistent with Singhvi et al. [3] who demonstrated that this variety significantly improves silk production. The recommended planting system, which includes tree-type and paired-row systems, is used by 80% of rearers, However, 20% of rearers adopted this system only partially, mainly due to their reluctance to change existing plantations, a similar trend was also observed by Kumar et al. [4]. While 83.33% follow the advised plant spacing, crucial for optimal growth whereas 16.67% partially adopted it. The partial adoption was attributed to resistance to modifying existing plants, the present findings were also supported by the observations made by Sharma et al. [5]. A significant portion of 63.30% apply the recommended Farm Yard Manure (FYM) of 20 MT/ha/year. However, 36.70% of rearers only partially adopted the practice, often due to limited access to cattle and the need to purchase manure. These results aligns with Patel et al. [6] where they highlighted that resource limitations significantly impact the adoption of FYM.

Although 40% of rearers fully adopting the recommended fertilizer application ratio of 350:140:140 kg/ha, 60% only partially adopted it due to knowledge gaps, limited fertilizer availability, and inadequate government subsidies. Jain et al. [7] identified similar barriers in their research. The adoption rates of various agricultural practices among rearers showed significant variability. While 53.33% did not adopt composting or vermicomposting, 26.67% partially adopted it and 20% fully adopted it, often due to reliance on trenching mulching systems, as noted by Rao et al. [8] and Singh et al. [9]. In contrast, 93.33% of rearers fully adopted recommended irrigation practices, with only 6.67% partially adopting them due to limited water availability, similar findings were also noticed by Kumar and Patel [10].

Intercropping was not adopted by 53.34% of rearers, with 23.33% partially adopting it and a smaller proportion fully adopting it, primarily due to difficulties in inter-cultivation operations as reported by Meena et al. [11]. Pest and disease management practices were fully adopted by 70% and 76.67% of rearers were partially adopted mainly due to insufficient knowledge and concerns about chemical toxicity. The present results were reflecting the findings of Patel and Sharma [12]. A significant majority (83.33%) of rearers fully embraced pruning and training schedules, largely due to their active involvement in extension programs. However, some rearers showed low adoption rates, mainly because of limited engagement with extension services and the high costs associated with inputs, which aligns with the findings of Singhvi et al. [3].

Overall, the study highlights the diverse levels of adoption of sericultural practices among bivoltine hybrid silkworm rearers, shaped by factors like resource availability, knowledge and extension support. These findings are consistent with recent research and offer valuable insights for enhancing the adoption of best practices in sericulture, ultimately aiming to improve productivity and sustainability in the industry.

3.2 Overall Adoption of Recommended Mulberry Cultivation Practices

Overall, the adoption levels of recommended mulberry cultivation practices show a diverse range of adherence (Table 2). The study reveals that, 43.33% of silkworm rearers demonstrate high adoption levels of recommended mulberry cultivation practices, indicating strong compliance with optimal techniques. Meanwhile, 40.00% of rearers show medium adoption, suggesting they follow some practices but neglect others. A smaller group of 16.67%, exhibits low adoption levels, likely due to constraints such as limited access to resources and knowledge. The overall adoption mean score is 15.53, with a standard deviation of 1.87, highlighting the variability in adherence to recommended practices among the rearers.

The results align with the studies by Dolli et al. [13] and Rao and Choudhry [14]. Similarly, Imrankhan [15] found that, most bivoltine hybrid silkworm rearers in Chitradurga district had fully adopted the recommended mulberry cultivation practices. Vijaya Prakash and Dandin [16] also reported that, the adoption rate of improved sericultural technologies were higher among bivoltine farmers compared to those rearing multi × bivoltine hybrids. Additionally, the characteristics of the farmers' profiles played a significant role in the adoption of bivoltine silkworm rearing.

3.3 Adoption of Improved Silkworm Rearing Practices

In silkworm rearing, the adoption of recommended practices demonstrates a high

level of compliance in certain areas. The results of adoption of improved silkworm rearing practices are depicted in the Table 3. The study shows that, nearly all silkworm rearers (96.67%) have adopted the practice of maintaining a separate rearing hall, essential for controlling environmental conditions and preventing diseases. High adoption rates were also observed for the type, size, and capacity of the rearing hall with 86.67% and 76.67% compliance, respectively ensuring adequate space and environmental management. Additionally, 93.33% of rearers follow the recommended orientation for the rearing hall, and 70% manage proper ventilation, both critical for a healthy rearing environment. Regular disinfection is practiced by 90% of rearers which significantly reducing the risk of disease transmission.

Shankar et al. [17] identified the existence of a separate rearing house as a crucial factor for the adoption of all related technologies. Similarly, Himantharaj et al. [18] noted that, during the second phase of the JICA project (1997-2002) in Erode district, Tamil Nadu, all farmers (100%) adopted separate rearing houses, shoot rearing and silkworm pest and disease management practices following the project's implementation.

The study reveals varied adoption rates for silkworm rearing practices. Recommended silkworm breeds are adopted by 76.67% of rearers, while the tray/shelf method and silkworm procuring practices are universally adopted at cent per cent. Chawki worm feeding practices are followed by 56.67% of rearers, indicating room for improvement compared to the 93.33% adherence to late-age silkworm feeding practices. The prescribed feeding schedule for each instar is followed by 80% of rearers. Bed cleaning and the use of growth hormones have lower adoption rates at 26.67% and 53.33%, respectively indicating areas where further training could be advantageous. Labour management is adopted by 60% of rearers, temperature management by 70%, relative humidity (RH) management by 63.33%, moulting management by 80%, integrated pest management by 70%, and integrated disease management by 80%. These adoption rates reflect a general adherence to best practices while highlighting areas where further improvements could be achieved.

Table 1. Adoption of specific mulberry cultivation practices by bivoltine hybrid silkworm rearers

Sl. No.	Particulars	Adoption (n=30)					
		Complete		Partial		Non	
		No.	%	No.	%	No.	%
1	Recommended variety (V-l)	30.00	100.00	0.00	0.00	0.00	0.00
2	Planting system (Tree type/ Paired row system)	24.00	80.00	6.00	20.00	0.00	0.00
3	Plant spacing (240 × 240cm/ (90+l 50) ×120cm)	25.00	83.33	5.00	16.67	0.00	0.00
4	Recommended FYM (20MT/ha/year)	19.00	63.30	11.00	36.70	0.00	0.00
5	Recommended fertilizers (350:140:140 kg/ha)	12.00	40.00	18.00	60.00	0.00	0.00
6	Composting\vermicomposting preparation	6.00	20.00	8.00	26.67	16.00	53.33
7	Irrigation management (4-6 day interval)	28.00	93.33	2.00	6.67	0.00	0.00
8	Intercropping with crops	7.00	23.33	7.00	23.33	16.00	53.33
9	Mulberry pest management (defoliators and sucking pests)	21.00	70.00	9.00	30.00	0.00	0.00
10	Mulberry disease management (foliar, stem and root diseases)	23.00	76.67	4.00	13.33	3.00	10.00
11	Pruning and training schedule and method	25.00	83.33	5.00	16.67	0.00	0.00

Table 2. Overall adoption of recommended mulberry cultivation practices

Sl. No.	Particulars	Bivoltine hybrid (n=30) Frequency	Percentage
1	Low	5	16.67
2	Medium	12	40
3	High	13	43.33
Mean score		15.53	
Standard deviation		1.87	

Table 3. Adoption of specific silkworm rearing practices by bivoltine hybrid silkworm rearers

Sl. No.	Particulars	Adoption (n = 30)					
		Complete		Partial		Non	
		No.	%	No.	%	No.	%
A	**Silkworm rearing house standards**						
1	Separate rearing hall	29.00	96.67	1.00	3.33	0.00	0.00
2	Type of rearing house	26.00	86.67	4.00	13.33	0.00	0.00
3	Size of rearing hall	23.00	76.67	7.00	23.33	0.00	0.00
4	Capacity of rearing hall	26.00	86.67	4.00	13.33	0.00	0.00
5	Direction of rearing hall	28.00	93.33	2.00	6.67	0.00	0.00
6	Proper ventilation management	21.00	70.00	9.00	30.00	0.00	0.00
7	Disinfection of rearing hall	27.00	90.00	3.00	10.00	0.00	0.00
B	**Silkworm rearing practices**						
1	Silkworm breed	23.00	76.67	7.00	23.33	0.00	0.00
2	Method of rearing (Tray /Shelf method)	30.00	100.00	0.00	0.00	0.00	0.00
3	Indenting / Procuring	30.00	100.00	0.00	0.00	0.00	0.00
4	Chawki worms feeding	17.00	56.67	10.00	33.33	3.00	10.00
5	Late age worms feeding	28.00	93.33	2.00	6.67	0.00	0.00
6	Times of feeding in each instar	24.00	80.00	6.00	20.00	0.00	0.00
7	Bed cleaning	8.00	26.67	16.00	53.33	6.00	20.00
8	Labour management	18.00	60.00	12.00	40.00	0.00	0.00
9	Temperature management	21.00	70.00	9.00	30.00	0.00	0.00
10	RH management	19.00	63.33	10.00	33.33	1.00	3.33
11	Moulting management	24.00	80.00	6.00	20.00	0.00	0.00
12	Integrated pest management	21.00	70.00	9.00	30.00	0.00	0.00
13	Integrated disease management	24.00	80.00	6.00	20.00	0.00	0.00
14	Silkworm growth hormones	16.00	53.33	6.00	20.00	8.00	26.67
C	**Cocoon yield and marketing**						
1	Mounting type	20.00	66.67	10.00	33.33	0.00	0.00
2	Mountages / 100 dfls	21.00	70.00	9.00	30.00	0.00	0.00
3	Density of mounting	18.00	60.00	12.00	40.00	0.00	0.00
4	Days required for harvest	28.00	93.33	2.00	6.67	0.00	0.00
5	Cocoon grading	10.00	33.33	19.00	63.33	1.00	3.33
6	Transportation and marketing	25.00	83.33	5.00	16.67	0.00	0.00
7	Byproduct utilization	4.00	13.33	26.00	86.67	0.00	0.00

The present findings were align with several studies, including Rao and Choudhary [14] Qadri et al. [19] and Mani et al. [20] who reported high adoption of shoot rearing technology in Erode district, Tamil Nadu. Hiriyanna (2005) and Banuprakash et al. [21] observed a high adoption rate of CSR bivoltine hybrid and $FC_1 \times FC_2$ silkworm breeds in Chitradurga district. Sreenivas et al. [22] emphasized the importance of cocoon price stabilization for technology adoption, while Qadri et al. [19] noted that higher literacy rates in Erode facilitated the adoption of advanced silkworm rearing technologies. Himantharaj et al. [18] reported that, the second phase of JICA project's (1997-2002) led to widespread adoption of separate rearing houses, shoot rearing and pest and disease management. Further, Lakshmananan and

Geetha Devi [23] noticed that even farmers outside the JICA program were also adopted recommended technologies. Radhakrishnan [24] observed high adoption rates in Udumalpet and Krishnagiri districts due to institute village linkage programme and catalytic development programme support. Shwetha and Shivalingaiah [25] highlighted the role of farmer profile variables in adoption. Further, Imrankhan [15] noted that educational status played a crucial role in understanding and adopting bivoltine hybrid silkworm rearing standards.

In cocoon yield and marketing, different practices exhibit varying levels of adoption among rearers. The use of mounting type is seen in 66.67% of cases and 70% adhere to the recommended number of mountages per 100 dfls, with 60% following the advised mounting density. Harvesting within the recommended timeframe is achieved by 93.33% of rearers. Cocoon grading is less common, with only 33.33% of rearers implementing this practice, while 63.33% either do not grade or only partially grade their cocoons. Transportation and marketing are effectively managed by 83.33% of rearers, showcasing strong commercial practices. In contrast, byproduct utilization is notably low, with just 13.33% making use of byproducts and 86.67% not utilizing them, highlighting a significant area for improvement in byproduct management. Meenal and Rajan [26] along with Deepa and Sujathamma [27] discovered that, the self-mounting method was extensively utilized by farmers in Tamil Nadu and Andhra Pradesh.

3.4 Constraints Faced by the Silkworm Rearers in the Adoption of Recommended Mulberry Cultivation and Improved Silkworm Rearing Practices

The constraints faced by sericulturists play a significant role in the adoption and effectiveness of improved practices. Significant challenges faced by rearers include high input costs, which are cited by 63.33% as a major barrier due to the prohibitive prices of essential materials like fertilizers, pesticides and rearing equipment. Additionally, 70% of rearers are affected by the poor quality of mulberry saplings, which hampers plant growth and reduces yields. Inadequate extension services, reported by 56.67% of rearers, limit access to technical guidance and support. Pest and disease management issues impact 40% of rearers, affecting the health of both mulberry plants and silkworms. Financial

Table 4. Constraints faced by the silkworm rearers in the adoption of recommended mulberry cultivation and improved silkworm rearing practices

Sl. No	Problems (n=30)	No.	%
A	**Mulberry production**		
1	Lack of knowledge on soil fertility for mulberry cultivation	14.00	46.67
2	Lack of knowledge on Method of planting	4.00	13.34
3	Lack of knowledge on Method of pruning	22.00	73.33
4	Non-availability of fertilizers on time	18.00	60.00
5	Shortage of irrigation water	23.00	76.67
6	Lack of knowledge on pest and disease management	14.00	46.67
B	**Silkworm rearing**		
1	Lack of knowledge on size of rearing house	13.00	43.33
2	Lack of knowledge on disinfection of rearing hall and rearing equipment	17.00	56.67
3	Chawki worms	11.00	36.67
4	IDM in silkworm rearing	19.00	63.34
5	IPM in silkworm rearing	3.00	10.00
6	Silkworm growth hormones	10.00	33.34
C	**Marketing**		
1	Cocoon grading	17.00	56.67
2	Cocoon prices	1.00	3.34
3	High transportation cost	4.00	13.34
4	Fluctuating market price	23.00	76.67
5	Exploitation by traders	13.00	43.34

constraints, affecting 50% of rearers, restrict investment in necessary inputs and improvements, while market fluctuations reported by 66.67% influence income stability and deter investment in quality practices. These constraints underscore the need for targeted interventions to enhance technical support, reduce input costs, and stabilize market conditions to provide stronger support for sericulturists.

To address challenges like unfavorable climatic conditions and pandemics, the government should set a support price, subsidize cocoon grading machines, protect farmers from private dealer exploitation and develop market infrastructure in all taluks. Further, marketing officials should help illiterate silkworm rearers receive cocoon prices via voice messages to stay updated on market rates. These solutions are proposed by bivoltine hybrid and multi × bivoltine hybrid silkworm rearers to address and overcome existing constraints. The present findings were aligned with Imrankhan [15] who also reported the different challenges faced by the silkworm rearers [28].

The Karnataka State Sericulture Research and Development Institute (KSSRDI), the Central Silk Board (CSB) and other agencies should address these issues to boost the adoption of bivoltine hybrid silkworm rearing practices and improve the economic situation of silkworm rearers by enhancing cocoon yield and net returns.

4. CONCLUSION

The study offers a detailed examination of the adoption rates for mulberry cultivation and silkworm rearing practices, highlighting both strengths and areas for improvement among sericulture rearers. Notably, high adoption rates were observed for critical practices such as maintaining separate rearing halls and utilizing recommended silkworm breeds, which are crucial for optimal production and disease management. Conversely, adoption rates are lower for other important practices, including composting, intercropping and proper bed cleaning, indicating areas where additional focus could enhance overall effectiveness. The study also identifies significant constraints impacting practice adoption. High input costs, such as those for fertilizers and rearing equipment pose a major barrier and limiting the ability of rearers to fully implement recommended practices. Further, Low quality mulberry saplings and inadequate extension services further exacerbate these challenges results in hindering plant growth and access to technical guidance. Financial limitations restrict investment in necessary inputs, while market fluctuations create instability that affects income and discourages investment in quality improvements. To address these issues, targeted interventions are needed, including enhanced technical support, cost reduction strategies and stabilization of market conditions. These measures could improve the adoption of best practices, thereby boosting productivity and sustainability in the sericulture industry.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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