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A review on status of the sericulture industry

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Abstract
Sericulture has left an indelible mark on the global textile industry and has been ingrained in human civilization for centuries. The delicate silk fabric has become a symbol of luxury and the industry has played an important role in cultural exchange and economic development between countries. The sericulture industry of Maharashtra state shows increasing trend in past few years and has substantial potential to provide opportunities of entrepreneurship and employment. This article provides an overview of the global state of the sericulture industry while focusing on the specific state Maharashtra for sericulture industry in India. Preserving tradition while pursuing innovation will ensure that the threads of silkworm farming remain woven into the fabric of human history and progress for generations to come.

Keywords: Sericulture, cultural exchange, economic development, tradition, Maharashtra state etc.

Introduction

Sericulture or Silkworm farming is an agriculture-based industry of global significance and its reflective impact on culture and commerce have made it an integral part of the human story. The origins of mulberry farming go back to the cradle of civilization, ancient China, where it developed around 2600 BC (San, 2014) [43]. Over the time, this industry has promoted cultural exchange and stimulated the economic growth of different countries. India, with its long past, has become a leader in silkworm farming, cultivating a legacy that spans millennia and is still deeply rooted in its cultural heritage. India is the second largest silk producer in the world. The country's sericulture industry employs about 9.76 million people in rural and semi-urban areas. Industry is one of the country's main foreign exchange earners. Silkworm farming operations in India spans over 52,360 villages (ISEPC, 2023) [26].

In India, the sericulture industry stands tall as one of the driving makers of silk, grasping different climatic conditions to develop different silk assortments, counting Mulberry, Tasar, Eri, and Muga (Chand *et. al*., 2023) [11]. However, the sericulture industry, both globally and in India, faces many challenges. The gradual decline of skilled silkworm farmers poses a serious threat to the industry's continuity as the younger generation is attracted to modern livelihoods (Majumdar *et. al*., 2017) [31]. Environmental concerns, along with climate change and natural disasters, are affecting silk production and cocoon quality, creating an urgent need for innovative practices and sustainable practices. Advances in biotechnology and genetic research offer hope for the development of disease-resistant silkworms and for improving overall silk yield (Nagaraju, 2002) [32]. The exploration of the global and Indian status of silkworm farming aims to uncover the threads that weave this ancient art into the fabric of human history, ensuring its continued influence on cultural identity. economic prosperity and sustainable development. The present article flashes on the status of the sericulture industry with special reference to Indian states in particular with Maharashtra.

Worldwide status

Many researchers from different parts of the world have worked on various aspects of sericulture. Many of them have mentioned the crucial data which is important while describing the status of sericulture industry. Nayar and Fraenkel (1962) [35] proposed a method of selecting host plants for silkworm farming based on chemical composition to obtain compatible host plants for silkworms that would ultimately give the best silk quality. Various aspects of the silkworm farming industry *viz*. mulberry farming, silkworm breeding, silkworm breeding, silkworm rearing, silk wrapping and weaving, collection of by-products and their processing provide employment on a large scale, and thus a source of livelihood for rural people and tribal (Gregory, 1994) [20].

In 2007 [33], Naguku *et al*., studied the effects of royal jelly-supplemented mulberry leaves on the weight of larvae, cocoons, shells and pupae, shell ratio, length and weight of filaments and number of breaks during unfolding. They concluded that the addition of royal jelly to mulberry leaves has the potential to improve the commercial quality of silk and could be used in silkworm rearing to improve yield. Furdui et.al, 2010 [18] examined 7 monoclonal strains of the Romanian silkworm *Bombyx mori* L. reared under specific conditions, ensuring the same microclimates, and fed the same mulberry leaves and they obtained results that showed great homogeneity, the difference being due to the variability and genotype characteristics of each individual of each race. De Bortoli, *et al*., (2012) [14] evaluated the effects of the addition of different concentrations of foliar additives, nandrolone decanoate, ascorbic acid, retinol palmitate and retinol acetate on larval biological parameters of *Bombyx mori* L. El-Yamani *et al*., 2018 [16] verified the effectiveness of mulberry leaves with acetone, petroleum ether, ethyl alcohol and *E. tirucalli* plant extract solution as nutritional additives on the biological properties of the species *B. mori*. Rateb and Abdel-Rahman (2018) [40] in Egypt also encountered similar results. According to them, local hybrid silkworms and treating mulberry leaves with water extract are considered easier and cheaper to raise mulberry silkworms. To improve the quality and quantity of cultured

cocoons, in silkworm culture, El-Yamani *et al*., (2019) tested antibacterial and antifungal activity on larvae using different concentrations of *Morus alba*, *Ocimum basilicum* and *Nigella sativa* seed extract. They found that these extracts suppressed bacterial and fungal disease. Demelash and Zemedkun (2020) presented the production status, opportunities, challenges and potential areas of silkworm farming in Ethiopia. Ethiopians have a strong passion for silk dating back to the country's earliest days. Currently, they regularly practice both the mulberry silkworm (*Bombyx mori)* and the Eri silkworm (*Samia cynthia ricini*), which mainly produces Eri silk in the country. Four regions in Ethiopia produce a total of 3 tons of silk per year. Due to favourable conditions such as two-dimensional rainfall patterns, ambient temperature, diversity of vegetation and other agroecological characteristics, Ethiopia has considerable potential for silk production.

According to Sandra *et al*, 2021 nanotechnology enhances the quality of silk fibre while also increasing the silkworm's survival rate and encouraging their growth and development. Studies have revealed that while certain nanomaterials have therapeutic capabilities, others are poisonous to the silkworm's tissues and organs. The quality, tissue healing, and overall survival rate of the silkworm have all been reported to improve with the addition of nanomaterials via food or injections. As per the study of Grzeskowiak *et al*., (2022), sericulture is completely in line with the trend of sustainable development due to the ecological nature of mulberry silkworm farming and mulberry cultivation, as well as the ability to manage and treat waste produced throughout the breeding process. So, the successful promotion and practical implementation of the concept of sustainable development in agriculture can be attributed to the production of silk. All these works indicate that sericulture industry plays a crucial role in economic development. So, it is considered as potential method for wellbeing of farmers in different parts of the world.

National status

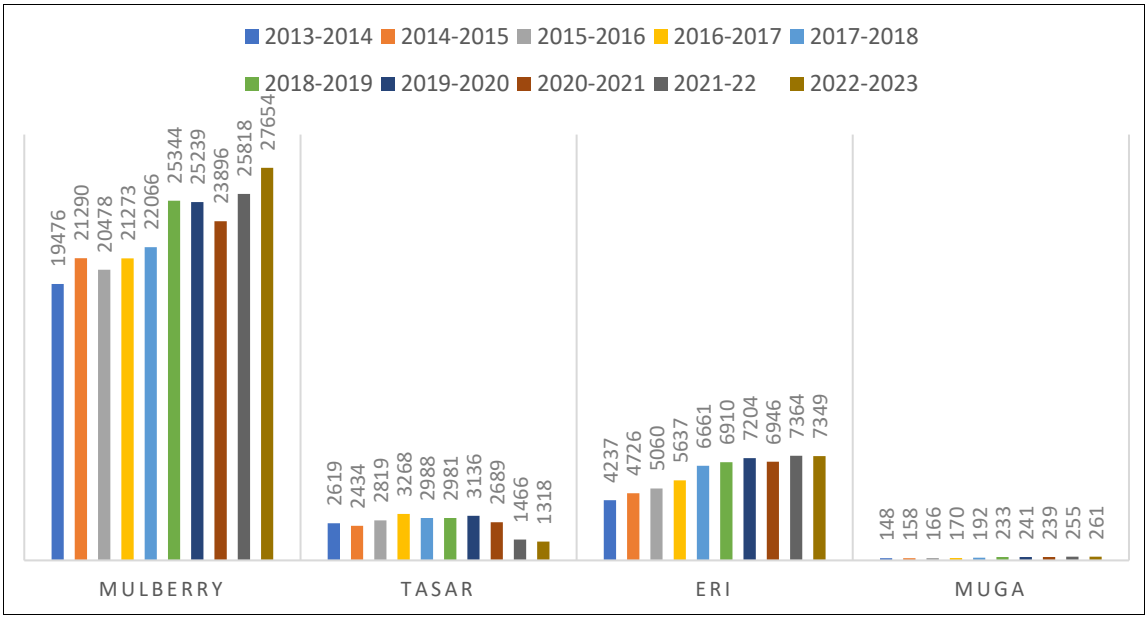
Sericulture plays a crucial role in rural economy because it guarantees normal business and occasional returns. Many Indian researchers have made extensive work about morphology, biology of *B. mori* L and various other aspects of sericulture. Hiware C. J (2006) [22] studied the effect of fortification of Mulberry leaves with homeopathic drug Nux Vomica on *Bombyx Mori* L. He studied the impact on larval, cocoon, shell and pupal weight, silk ratio, average filament length and denier, and number of breakages during reeling. Gangophadhyay (2009) provided a brief review of the present status of the sericulture industry in India. They concluded that sericulture industry plays a role in national economy, rural development, women empowerment and employment generation. They have also suggested some possible approaches for the development of sericulture industry in India. Naphade *et al*., (2010) [34] concluded that mango tree twigs mountages play a crucial role in saving the cocoon crop and are easily available and easy to use for farmers. Bhalerao *et al*., (2011) [5] conducted a survey on weed infestation in mulberry garden in three different seasons, namely rainy, winter, and summer during study period of 2004-2005 and 2005-2006 and observed the occurrence of 58 weeds species belonging to 16 families. Shinde *et al*., (2012) [46, 48] studied the impact of spacing, fertilizer on the productivity of Mulberry (Morus Alba L.) V1 Variety and observed that the impact of V3 (3'x 1') spacing type and T3 (NPK) fertilizer treatment on leaves weight as well as height of plant which showed positive results. Avhad S. B and Hiware C. J (2013) [1] carried out a field investigation on the seasonal incidence of frequently occurring leaf eating pests of mulberry from Aurangabad district of Maharashtra. They observed that, that, different pests such as leaf roller, Bihar hairy caterpillar, cutworms, Red hairy caterpillar, Jassid / leaf hopper, Southern green stink bug / Pentatomid bug, Tree hoppers, Litchi bug, wasp moth and wingless grasshopper were damaging the Mulberry cop from the study area which causes heavy economical loss to sericulture farmers. The leaf extracts along with biologically active principles from three medicinal plants such as Pakarkai (*Momordia charendia*), Tulasi (*Ocimum sanctum*) and Nilavembu (*Andrographis paniculata*) were tested for their potential in improving silk production (Karthikairaj *et al*., 2013) [28].

Avhad *et al*., (2013) [2] observed severe cocoon loss due to infestation and stinking smell of mucus layer (both wet and dry conditions) released by the Giant African snail, *Achatina fulica* on mulberry plant. The silkworm showed an abhorrence towards nourishing on such leaves and as result, significant amounts of collected leaves were wasted without changing over in to silk cocoons. Shinde *et al*., (2014) [47] studied the impact of spacing and fertilizers on the production of M5 Mulberry variety and observed that, the impact of M5 (3'×3') spacing type and T3 (NPK) fertilizer treatment on leaves weight as well as height of plant which showed positive results. Avhad *et al*., (2014) [2] Impact of Soil abiotic factors on population fluctuation of soil and plant parasitic nematodes associated with mulberry, *Morus alba* L. from Gangapur, Aurangabad and observed that soil abiotic factors (temperature, soil moisture, pH) have a direct effect on the nematode population. According to the report of Central silk board (2015) [9], India has the unique distinction of being the only country producing all the five known commercial silks, namely, mulberry, tropical tasar, oak tasar, eri and muga, of which muga is unique and prerogative of Indian culture due to its golden yellow glitter. In India the oldest cottage industry is the silk handloom industry. Sericulture in Odisha is capable of providing a strong support for under privileged people as dependable and additional avenues of income at frequent intervals. Tribes and poor can accept sericulture as subsidiary occupation for their economic gain, (Sahu, 2015) [42]. Different concentrations of *O. sanctum* extract are found to be most effective over the control *O. sanctum* extract has growth promoting effect on silkworm, which helps to enhance the commercial qualities of silk and can be used in sericulture for yield improvement, (Padma Sree Vidya Devi and Ramani Bai. 2015) [37]. The Mulberry silkworm *Bombyx mori* L. fifth instar larvae were feed on mulberry leaves fortified with plant extract of *Zizipus jujuba* L. with concentration different concentrations and dilutions and it is observed that there is improvement in silk quality and quantity which helps farmers to improve their economic status. (Avhad and Hiware, 2016) [3, 23, 24]. Jadhav *et al*., (2016) studied the effect of medicinal plant extract of *Asparagus recemousces* and *Astracantha longifolia* as food supplement of silkworm *Bombyx mori* L. for improved cocoon traits and observed variable consumption rate in *Asparagus* and *Astracantha* plant extract treatment.

Sericulture industry requires low investment and it helps to earn higher returns in short gestation period, due to this the farmers are getting attracted to this sector and it is a best tool to improve the rural economy as well as to improve their living standards, (Naik, 2017). Shinde *et al*., (2017) conducted comparative studies on the performance of mountages on cocoon quality of *Bombyx Mori* L. and observed that Shindi branches showed positive impact on the quantity of cocoons per branch, less double cocoons, shell ratio, shell weight, length and weight of filament and denier. Buhroo *et al*, (2018) [7] observed that the proper use of by-products and wastes from the silkworm farming industry can generate additional income beyond silk. They also examined the recent advances in the overall use, diversification and value-adding of resources in expanding the sustainability of the sericulture industry. Chanotra *et al*., (2019) [12] carried out a review on the role of sericulture in the upliftment of rural livelihood. They have concluded that, sericulture plays a crucial role in employment generation and empowerment of socially privileged groups. Advanced techniques such as gene therapy, gene editing, transgenic technology etc. are being used to address various challenges in sericulture *viz*., producing transgenic silkworms with increased cocoon quality and quantity, to use silk as a material in medical and pharmaceutical industry etc., (Sharma *et al*., 2022) [45].

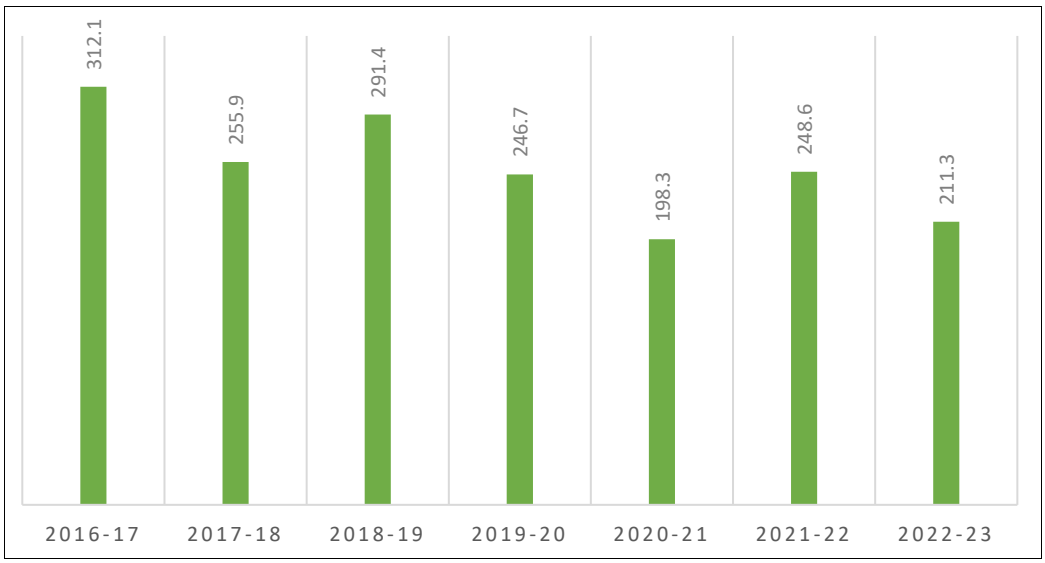
Table 1: Commercially exploited sericigenous insects of the world and their host plants. (CSB Report, 2023) [8].

Common Name	Scientific Name	Origin	Primary Food Plants
Mulberry Silkworm	*Bombyx mori*	China	*Morus indica*
			M. alba
			M.multicaulis
			M.bombycis
Tropical Tasar Silkworm	*Antheraea mylitta*	India	*Shorea robusta*
			Terminalia tomentosa
			T. arjuna
Oak Tasar Silkworm	*Antheraea proylei*	India	*Quercus incana*
			Q. serrata
			Q. himalayana
			Q. leuco tricophora
			Q. semecarpifolia
			Q. grifithi
Oak Tasar Silkworm	*Antheraea frithi*	India	*Q. dealdata*
Oak Tasar Silkworm	*Antheraea compta*	India	*Q. dealdata*
Oak Tasar Silkworm	*Antheraea pernyi*	China	*Q. dendata*
Oak Tasar Silkworm	*Antheraea yamamai*	Japan	*Q. acutissima*
Muga Silkworm	*Antheraea assama*	India	*Litsea polyantha*
			L. citrata
			Machilus bombycina
Eri Silkworm	*Philosamia ricini*	India	*Ricinus communis*
			Manihot utilisma
			Evodia fragrance
Mulberry Silkworm	*Bombyx mori*	China	*Morus indica*
			M. alba
			M.multicaulis
			M.bombycis



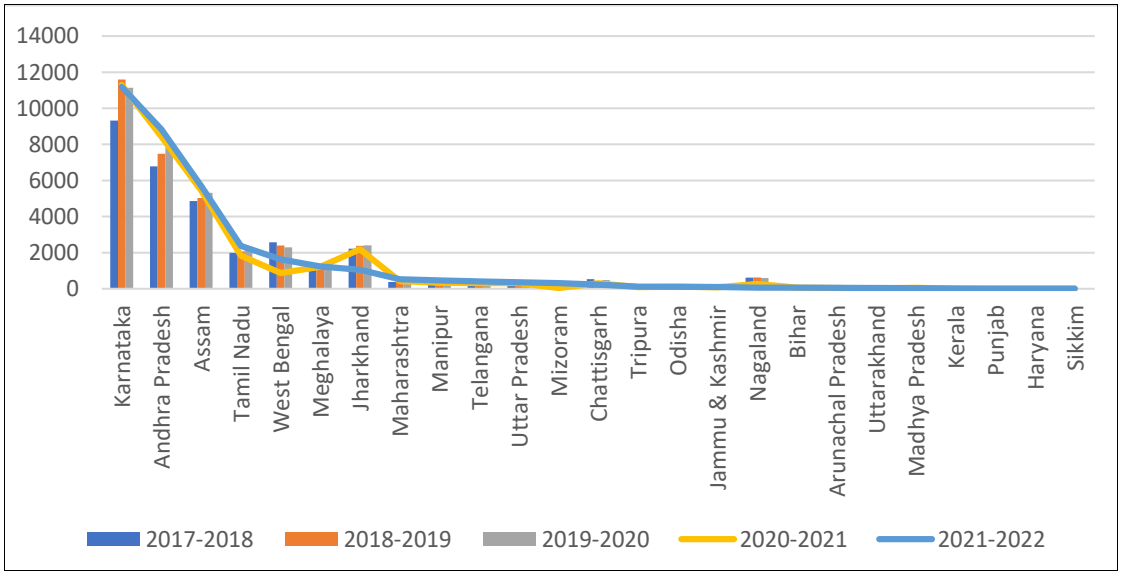
Graph 1: Silk Production in India – Last 10 Years (CSB Report, 2023) [8].

According to Graph 1, Production of Mulberry silk has been increased from 19,476 MT to 27,654 MT. Production of Tasar silk showed decrease from 2619 MT to 1318 MT. Production of Eri Silk has increased from 4237 MT to 7349 MT. Muga Silk Production showed increase of 148 MT to 261 MT. So, The Silk production has shown an encouraging progress in last 10 years.



Graph 2: India's Silk & Silk Products export Trend in US $ Millions. (ISEPC, 2023) [26].

According to Graph 2, Silk Products export trend has shown decrease from 312.1 million $ to 211.3 million $. So, the export of silk product needs to be increased by proper marketing and branding according to the needs of various communities across the world (ISEPC, 2023) [26]. Sericulture is an agriculture-based enterprise that plays an important role in shaping the economic destiny of the rural world and fits very well into the rural structure of India, where agriculture continues to be the main industry.



Graph 3: State wise raw silk production in India for during 2017-2022 in metric tons (Statista Report 2023, CSB Report 2021) [10, 50].

Table 2: State wise raw silk production in India for during 2017-2022 in metric tons (Statista Report 2023, CSB Report 2021) [10, 50].

Sr. No.	State	2017-2018	2018-2019	2019-2020	2020-2021	2021-2022
1.	Karnataka	9322	11592	11143	11292	11,191
2.	Andhra Pradesh	6778	7481	7962	8422	8834
3.	Assam	4861	5026	5316	5450	5700
4.	Tamil Nadu	1984	2072	2154	1834	2373
5.	West Bengal	2577	2394	2295	872	1632
6.	Meghalaya	1076	1187	1192	1213	1234
7.	Jharkhand	2220	2375	2402	2185	1052
8.	Maharashtra	373	519	428	428	523
9.	Manipur	388	464	504	327	462
10.	Telangana	163	224	297	309	404

11.	Uttar Pradesh	292	289	309	316	355
12.	Mizoram	83.6	92	104	43	315
13.	Chhattisgarh	532	349	480	300	224
14.	Tripura	87	230	111	86	113
15.	Odisha	116	131	137	117	108
16.	Jammu & Kashmir	132	118	117	80	99
17.	Nagaland	615	620	600	264	59
18.	Bihar	63	55	56	58	56
19.	Arunachal Pradesh	54	59	64	43	53
20.	Uttarakhand	35	36	40	25	42
21.	Madhya Pradesh	103	100	61	47	28
22.	Kerala	15	16	13	5	9
23.	Punjab	3	3	3	1	3.5
24.	Haryana	0.7	0.7	1	1	0.75
25.	Sikkim	0.001	0.4	1	0.08	0.03

According to Graph 3 & Table 2, The south Indian state of Karnataka was the leading raw silk producer during 2017-2022. Andhra Pradesh, Assam, Tamil Nadu, West Bengal, Meghalaya showed constant production for 5 years. Sikkim showed the least production of raw silk. Remaining states showed decreasing graph of raw silk production. Maharashtra state showed increasing trend of silk production.

Status of Sericulture Industry in Maharashtra State:

Many researchers from different parts of Maharashtra have studied various aspects of sericulture industry. Hiware *et al*., (2004), carried out a study on status of sericulture industry in Aurangabad district, Maharashtra. He concluded that, there is increasing trend in sericulture industry of Aurangabad district and total 90 villages with 277 beneficiaries were conducting sericulture practices. Dewangan (2013) [15] investigated that sericulture fulfils the opportunities of livelihood for tribal. He concluded that, Sericulture is the activity of low investment and high output. The history of sericulture industry in Maharashtra extends from Satavahana Empire which was an Indian dynasty based in Dharanikota and Amaravati in Andhra Pradesh as well as Junnar (Pune) and Pratisthan (Paithan) in Maharashtra. Maharashtra is a non-traditional mulberry silk producing state in the country occupying 1st position amongst non-traditional state (Hiware C. J, 2016) [22, 24]. Sanadi and Jadhav (2016) carried out a study on socioeconomic status and health risks among sericulture industry workers of Maharashtra. Hugar *et al*., (2016) [25] stated that, BAIF has conducted several activities related to different aspects of natural resource management with sericulture through number of projects in the field of research, extension, training, technology development and demonstrations. Nimgare *et al*., (2017) [36] conducted a study on status of the sericulture industry in Maharashtra. They concluded that the production of Mulberry and Tasar silk has increased from 2004-05 to 2013-14. Pathare and Hiware (2017) [38] carried out a study on the participation of women in sericulture activities of Ahmednagar district. They observed that sericulture plays a crucial role in empowerment of women and farmers of Ahmednagar district. Jakkawad *et al*., (2019) [27] conducted a study to understand the status of sericulture industry of Aurangabad district. They studied about Socio-personal characteristics of the Sericulturists and sericulture practices adopted by farmers. Mahareshim Campaign (2020) [30] was organized by Government of Maharashtra to create awareness regarding silkworm farming and to encourage farmers for silkworm production. Khade *et al*., (2021) [29] studied the effect of methanolic extract of *Achyranthes aspera* Linn. on the larvae of silkworm, *Bombyx mori* L. and observed the increase in feed consumption rate of the larvae in 25%, 75% concentration. A study on the relationship between profile of sericulture farmers with impact of sericulture enterprise was conducted by Joshi *et al*., (2021) in Nanded district of Marathwada region. Kadu *et al*., (2022) conducted a study to assess the silkworm cocoon production and its profitability in Nagpur district of Maharashtra. They studied the socio-economic aspects of sample farmers such as family type, education, family size, education status, land use pattern, and cropping pattern etc. The Maharashtra state is having a good potential for sericulture and to attempt the generation of quality silk. As the state is nontraditional in silk production practices, it is essential to extend incentives on different exercises as given by traditionally silk producing states.

Role of sericulture in empowerment of farmers & women

The sericulture industry provides high-income employment for the rural masses. Becoming a rural enterprise that uses a lot of labour industry, creating qualitative and quantitative changes in poverty reduction with a chain of job creation from unskilled agricultural workers to skilled artisans from all walks of life in the countryside. (Savitri *et al*., 2013). Women contribute in generation of family income through silkworm farming. If the rural household must be made economically viable and self-sufficient unify job creation and income through rural women must be given the highest priority (Prabha Sekhar and Ravi Kumar 1988) [39]. A study on the empowerment of farmers through sericulture industry from Aurangabad district was conducted by Hiware C. J (2016) [23, 24]. They concluded that, the participation of rural communities has led to community development and economic empowerment. Dar *et al*., (2020) [13] conducted a study on status of sericulture in Kargil, J & K. They concluded that sericulture is a viable option for farmers of Kargil. According to all these works, Sericulture industry plays an important role in the empowerment of rural communities and women. It can provide a substantial side income for the farmers and can flourish their lifestyle.

Conclusion

The Present article has attempted to assemble all the relevant information regarding status of the sericulture industry. In India, Sericulture is mostly a town-based industry providing employment opportunities to a large

portion of the population. Despite being seen as a secondary occupation, industrial advancements have enabled its intensive scale and sufficient income generation. It can also provide steady pay to farmers. It is one of the noticeable undertakings, which gives full time business to whole family advertising tall pay and superior standard of living. But there is a wide crevice between production of silk in India, its utilization and export trend. This offers a great scope for the expansion of sericulture industry. The production of silk and use of silk products can be increased by creating awareness, providing guidance, stimulation and more financial assistance to silk producers.

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